Determining the Contributions to Price Discovery of China Cross-listed Stocks

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Abstract

This paper studies the price-discovery process for a number of Chinese cross-listed stocks. For the stocks cross-listed on the New York Stock Exchange (NYSE) and Stock Exchange of Hong Kong (SEHK), we find that the prices on these two exchanges are cointegrated and mutually adjusting. The SEHK makes more contributions than the NYSE to the price-discovery process. The average SEHK share of contributions are 54.5% and 63.9% computed from Gonzalo and Granger (1995) permanent-transitory (PT) model and Hasbrouck (1995) information share (IS) model respectively. Moreover, the NYSE's share of contributions is negatively related to the stock's listing on the China stock exchanges. For stocks cross-listed on SEHK and the China stock exchanges, we find that only a few stocks' prices are cointegrated at the intraday level. For the cointegrated stocks, the China market plays a dominant role in the price-discovery process. The cointegration test of daily H share and A share prices suggests an integration trend between the two stock markets.

摘要

這篇文章研究同時在兩地上市的中國股票的價格發現機制。 對於在紐約證券交易所和香港交易所同時上市的股票，我們發現同一只股票在兩個交易所的價格是共積(cointegrated)和相互調整的。 香港交易所對價格發現過程的貢獻要大於紐約證券交易所。 從 Gonzalo-Granger(1995)的永久-短期（Permanent-Transitory）模型和 Hasbrouck (1995) 的信息份額（Information Share）模型計算得出香港交易所價格發現的貢獻分別為 54.5%和 63.9%。 此外，紐約証交所對同時在兩地上市中國股票價格發現的貢獻與股票是否在中國內地證券交易所上市負相關。 對於同時在香港和中國內地上市的股票，使用日內（Intraday）數據，我們發現只有少數股票在兩地的價格是共積的。 對於共積的股票，我們發現中國市場在價格發現過程中起支配作用。 我們用每日(daily) H 股和 A 股的價格作共積分析，發現兩地市場有逐漸整合的趨勢。

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List of Abbreviations

ADRs	American Depositary Receipts
CSRC	China Securities and Regulatory Commission
GDRs	Global Depositary Receipts
NASDAQ	National Association of Securities Dealers Automated Quotations
NYSE	New York Stock Exchange
SEHK	The Stock Exchange of Hong Kong
SOE	State-owned enterprise
SSE	Shanghai Stock Exchange
SZE	Shenzhen Exchange
A share	The shares are issued by China-incorporated firms in China stock exchanges, and denominated and traded in China RMB.
H share	The shares are issued by China-incorporated firms in the Stock Exchange of Hong Kong, and denominated in China RMB and traded in HK dollars.

Chapter 1. Introduction

With the globalization of the world financial markets, more and more firms choose to list and trade their shares in more than one country. This has raised several interesting questions, such as the motivation and rationale of international cross-listing, and the effect of the cross-listing on the domestic stock performance. Recently, the study of the price-discovery contribution of foreign exchange to individual stocks has been prompted, and the explicit assessment of the relative contributions of home and foreign market in the price-discovery process has started to receive attention. Not only the price-discovery contributions are examined for stocks cross-listed in developed financial markets, but the role of foreign markets in the price discovery for cross-listed stocks from emerging markets is investigated very recently. In this study, we examine a number of Chinese stocks that are cross-listed on the Stock Exchange of Hong Kong (SEHK) and New York Stock Exchange (NYSE), as well as stocks cross-listed on China stock exchanges (Shanghai Stock Exchange and Shenzhen Exchange) and SEHK to investigate the relative price-discovery contribution of each market.

Previous studies on the price discovery for stocks from emerging markets cross-listed on developed markets are limited. This is mainly due to the unavailability of high quality intraday data. Kadapakkam, Misra and Tse (2003)

and Lieberman, Ben-Zion and Hauser (1999) all use daily data to investigate this issue. In our study, the intraday data is used for stocks traded in SEHK and China stock exchanges. For stocks cross-listed on SEHK and NYSE, since there is no overlapping trading period, we employ daily data in our analysis.

We study a sample of eight China-backed firms cross-listed on SEHK and NYSE. These 8 firms listed as American Depository Receipts (ADRs) in NYSE. Since the ADRs could be freely converted to H share, the arbitrage forces equalize the prices in NYSE and SEHK. We find that the two prices are cointegrated with one common factor. We use two models, Hasbrouck (1995), and Gonzalo-Granger (1995) models, to compute each market's price-discovery contribution. The empirical results obtained from the two models are quite similar. We find that on average the SEHK contributes more to the price-discovery process than the NYSE for these eight China-backed stocks. Moreover, the NYSE contributes more if the stock is not listed on the SSE or SZE.

For stocks cross-listed as H share on SEHK and A share on the China stock exchanges, we use intraday data at a 15-minute interval in the overlapping trading period of both markets. We find that, taking into account of the market movement, only a few stocks' H share and A share are cointegrated with each other. For these stocks, the China stock market plays a dominant role in finding the efficient price.

The study of H share and A share with daily closing price in three different periods shows that China stock market and Hong Kong stock market are becoming more integrated in recent years.

This paper is the first to use cointegration and vector error correction model to investigate the price-discovery contribution of China cross-listed stocks. It also systematically reviews the China overseas listing. The empirical results mentioned above have implications for investment and portfolio management.

We organize the rest of the paper as follows. Chapter 2 reviews the literature of international cross-listing. Chapter 3 provides the background of Chinese firms' overseas listings. Chapter 4 investigates the price-discovery process of China-backed stocks cross-listed on SEHK and NYSE. Chapter 5 studies the cointegration and the price-discovery process of stocks cross-listed on SEHK and China SSE or SZE. Chapter 6 concludes the paper.

Chapter 2. Literature Review

In the past two decades, a number of firms chose to list their stocks on foreign exchanges. This trend is also enhanced by the competition among various stock exchanges to attract the order flow (i.e., trading volume). The popularity of this cross-listing has prompted a lot of studies on this topic with different focuses. Earlier studies investigate the effect of cross-listing on the domestic stocks performance and try to find the cause for such an action. Recent studies focus on the interaction between the two prices on different exchanges, with an intention to find out in which market the price-discovery process mainly occurs and whether the foreign exchanges contribute to the price-discovery process.

In this part, we will review the literature of the previous studies on international cross-listing, the price discovery of cross-listed stocks, and the literature related to China cross-listed stocks.

2. 1 The Benefits of Cross-listing

Early studies of cross-listing focus on the rationale and benefits of cross-listing. By investigating the price and return performance before and after the cross-listing, they argue that there are mainly two benefits of cross-listing.

2. 1. 1 Reducing the cost of capital

Survey results show that the motivation to list abroad, according to many managers, is to gain access to the foreign capital market and to increase the recognition of the company (Baker et al., 2002; Mitoo, 1992). According to Merton (1987), investors do not have equal information, and hence they invest only in the securities they are familiar with. Therefore, all else being equal, an increase in the number of the investors' knowing about the firm lowers investors' expected return. This "investor recognition" factor, called by Merton, reduces the "shadow cost" of not knowing about a security. An increase of investor recognition is associated with cross-listing on foreign exchanges, and is expected to reduce a firm's cost of capital.

Several studies have documented that the stock return pattern are consistent with this argument after the cross-listings. Alexander, Eun, and Janakiramanan (1988) examine the behavior of stock return surrounding the international-listing for a sample of 34 firms. They divide the sample into two groups, one is Canadian firms and the other is non-Canadian firms. They find that the sample of non-Canadian firms has shown a decline of expected return after the international listing. For the sample of Canadian firms, a decline of expected return is noted. However, it is statistically insignificant and is much smaller than that of non-Canadian firms.

Foerster and Karolyi (1993) examine a group of Canadian stocks listed on the

U.S. market. They find that during the 100 days before the week of interlisting on the U.S. market, the risk-adjusted stock prices of Canadian firms rise by over 9.4% on average and by an additional 2% around the interlisting date, but followed by a corresponding drop of 9.7% in the 100 days after the interlisting. Foerster and Karolyi (2000) examine 333 global equity offerings with American depository receipts from 35 countries, and conclude that these equities under-perform the local market benchmarks of comparable firms by 8-15% over the three years after the issuance.

Errunza and Miller (2000), Karolyi (1998), and Miller (1999) do similar studies and find a decline in the expected return after the international listing. In addition, Kadlec and McConnell (1994) and Foerster and Karolyi (1999) test the investor recognition hypothesis, and show that the number of shareholders increases after the cross-listing, and the expected returns are lower compared to the returns before the listing. In addition, Amihud, Mendelson and Uno (1999) demonstrate that lower returns are associated with an increase in the number of shareholders for a sample of Japanese stocks cross-listed on the U.S. exchanges.

2.1.2 Enhancing the liquidity

Apart from a reduction in the cost of the capital, there are other benefits

associated with cross-border listings, such as an increase of liquidity in the domestic market. A market is considered to be liquid if transactions can be executed rapidly with little impact on prices. The enhanced liquidity after the foreign listing is mainly attributed to the global competition for order flow (i.e., trading volume). This competition causes exchanges to look for ways to improve their trading process continuously. Several studies document this phenomenon. Chowdhry and Nanda (1991) show that the global listing is associated with increased liquidity. Foerster and Karolyi (1999) find that the bid-ask spreads in Canada decrease after the cross-listing of Canadian stocks in the United States. Brockman and Chung (1999) find that bid-ask spreads are significantly lower and depths are significantly higher for Hong Kong firms which choose cross-listing on the London Stock Exchange than those only listed on local market, even controlled for price difference, volume, return variance and inter-temporal patterns.

Several studies also document that the trading volume of the stocks in domestic market increase after their cross-listing on a foreign market. Foerster and Karolyi (1993) find that Canadian interlisted stocks' average trading volume almost doubled in the month after interlisting. Smith and Sofianos (1997) find that the home-market value of trading increases substantially after the firms list on the NYSE.

2.2 The price-discovery process of cross-listed stocks

When a stock is listed and traded in more than one market, the behavior of the prices in each market is worth examining. Since the stock price is based on the same fundamental asset, due to the law of one price, we expect them to be the same in each market. However, although the technological progress has enhanced the globalization and integration of world financial market, there is still a time difference for the news to come into the markets and be incorporated and reflected in each market's price. Therefore, the price of the same stock may deviate across the markets. Different trading values create the arbitrage opportunities, and arbitrage activities will keep the prices in each market from drifting apart. Therefore, the prices in each market will share a common stochastic factor. This is referred to as the implicit efficient price (Baillie, et al. 2002).

The implicit efficient price is determined by the news which affects the prices of all market permanently, but not by the noise that affects price in a specific market. The search for this implicit efficient price is the price-discovery process. According to Schreiber and Schwartz (1986), price discovery is the key function of a stock exchange. For a cross-listed stock, whether the foreign market contributes to the price-discovery process and the extent of this contribution is investigated recently.

2.2.1 The contribution of regional markets to the price-discovery process

The contribution to the price discovery of different markets is first studied with dually listed stocks within the United States. This can date back to 1979 by Garbade and Silber. They test whether the dually listed equities on the New York Stock Exchange and the regional stock exchanges share a common equilibrium price. They introduce the dominant and satellite markets and find that the NYSE performs like a dominant market. It is where most of the news and information come to public. The price in the regional exchanges adjust more to the price in NYSE, however, the regional market is not pure satellite, the price in NYSE is also adjusted to the price in regional markets.

Harris, deB., McInish, Shoesmith, and Wood (1995) examine the relative contribution of the NYSE and regional exchanges to the price discovery of a U.S. stock. Using an error correction model for IBM's prices in three exchanges, they find that not only do prices on the Pacific and Midwest exchanges respond to deviations from NYSE prices, but NYSE prices also respond to deviations from prices on regional exchanges, though the magnitude of the adjustment in NYSE is smaller than those in regional exchanges.

2.2.2 The contribution of foreign market to the price-discovery process

In recent decades, international cross-listing has gained increasing popularity, and the number of American Depository Receipts (ADRs) and Global Depository Receipts (GDRs) issues increases rapidly. Not only the firms from developed countries list their stocks on leading financial markets, such as the U.S. and U.K., but the firms from emerging market also list their shares on these exchanges. With more and more firms cross-list their stocks abroad, studies have been prompted for the role of foreign market to the price discovery of these cross-listed stocks.

Earlier studies on dual-listing within the U.S. have paved the way for international cross-listing. Using the method similar to Harris, deB., McInish, Shoesmith, and Wood's (1995), Eun and Sabherwal (2003) study the contribution of the U.S. stock exchange in the price discovery for 62 Canadian firms listed on the Toronto Stock Exchange and one of the U.S. exchanges with quotes of every 10 minutes. They find that prices on both exchanges are cointegrated and mutually adjusting to each other and the average U.S. share of contribution is 38.1%. They also analyze the factors that affect the extent of the U.S. stock exchange's contribution to the price discovery and find that the U.S. share of price discovery directly relates to the U.S. share of trading volume and to the ratio of proportions of informative trades in the U.S. exchanges and the TSE, and inversely related to the ratio of bid-ask spreads.

Pascual, Pascual-Fuste and Climent (2001) analyze five Spanish stocks cross-listed on the NYSE during the daily 2-hour overlapping trading hours of both exchanges. They use the error correction model to examine the simultaneous price series on both markets. They calculate the Hasbrouck (1995) information share, and find that the NYSE contribution to the price discovery varies from 1% to 3%, which is relatively small.

Grammig, Melvin and Schlag (2005) study the contributions of the Frankfurt and the New York Stock Exchange for three German stocks with high frequency quotes. They report that the bulk of price discovery during the overlapping period occurs in the German market. The U.S. contribution of the price discovery is 1% for Deutsche Telecom, 9% for Daimler-Chrysler and 20% for SAP. Their empirical evidence supports that the price is mainly determined in the home market.

Lieberman, Ben-Zion and Hauser (1999) examine the price behavior of six firms dual-listing their stocks in Israel and the U.S. with daily closing price. They use an error correction approach and find that prices in different market are cointegrated, and arbitrage opportunities are generally not available. They also find that the effect of Israeli market on the share prices in the U.S. is stronger than the reverse direction. Although they do not use the price discovery in their analysis, their result indicates that the Israeli market contributes more to the price-discovery process.

In addition to the studies on stocks cross-listed on both developed financial market, the role of foreign financial center in the price-discovery process for stocks from emerging market is also investigated. Kadapakkam, Misra and Tse (2003) examine the Indian stocks dually listed on London Stock Exchange as Global Depositary Receipts (GDRs). They use the daily open and close price data to compute the information share of London and Mumbai market with two common factor models. They find that London and Mumbai prices are cointegrated, and that each market contributes almost equally to the price-discovery process. Via a cross-sectional analysis, they find that GDRs' market's contribution to price discovery increases with the foreign institutional investment of the firm and the size of the GDRs issue.

Ding, Harris, Lau and McInish (1999) investigate the price discovery of a large Malaysian conglomerate traded both in Kuala Lumpur Stock Exchange (KLSE) and the Stock Exchange of Singapore (SES). Using the Gonzalo-Granger (1995) common long-memory factors, they find that nearly 70% of the price discovery occurs in the home country and 26-32% can attribute to the SES. They also find a strong error correction of Singapore prices to Malaysian prices, but only a weak error correction of Malaysian prices to Singapore prices.

2.3 Previous studies on Chinese cross-listed stocks

In the past decade, there is a rapid increase in the number of Chinese firms listing in the international markets. Many Chinese companies have listed their shares on several overseas exchanges. The Chinese firms' cross-listings have also drawn academic attention.

Wang and Jiang (2004) examine a group of stocks cross-listed on the Mainland exchanges as A share and on the Stock Exchange of Hong Kong as H share. They find that A share returns are subject to the risk and the investor sentiment that is specific to the Mainland stock exchanges. However, H share returns are subject to the market-specific risk and investor sentiment in both Hong Kong and Mainland stock market. In addition, they find the price discount of H share relative to A share is highly correlated with the domestic and foreign stock market indices and the relative market illiquidity. Their empirical studies also show that H share price discount is positively correlated with the expected devaluation of the Chinese currency.

Previous studies on the market contribution to the price discovery of cross-listed Chinese stocks are very limited. One example is Xu and Fung's (2002) studies on China-backed stocks that are cross-listed on the Stock Exchange of Hong Kong and the New York Stock Exchange. They use a bivariate generalized autoregressive

conditional heteroskedasticity (GARCH) model to study the information transmission between the two markets. The empirical results indicate that there is a significant mutual feedback of information between the two markets in terms of pricing and volatility. Stocks listed on the Hong Kong exchange appear to play a more significant role of information transmission in the pricing process, whereas stocks listed on the NYSE play a bigger role in volatility spillover. In our paper, we will work along this line with cointegration and error correction model.

Chapter 3. China Overseas Listing[1]

Since the establishment of Shanghai Stock Exchange and Shenzhen Exchange in early 1990s, the Chinese equity market has expanded dramatically. By the end of Dec. 2003, there are 1285 companies listed on Shanghai Stock Exchange and Shenzhen Exchange with a total market capitalization of 4274.9 billion RMB, which is 390 times the market value of 1991. Although the Chinese equity market has developed swiftly, it cannot satisfy the huge demand for capital arising from the rapid growth of the economy. Therefore, many firms chose to list overseas to raise the needed capital.

3.1 The history of overseas listing

China-backed companies have begun to list abroad in early 1970's, mainly in Hong Kong. According to the statistics of SEHK, eight China-backed companies listed in 1970's and eight in 1980's. These companies are usually government-backed firms and represent the interests of China's leading ministries, provincial and municipal authorities. Therefore, they got a nickname of "Red Chips". The Red Chips are often diversified conglomerates such as CITIC Pacific and Shanghai Industrial Holdings, which have various lines of business. These

[1] Although Hong Kong is one part of China after 1997, we consider SEHK an international exchange compared with SSE and SZE.

companies are usually incorporated outside China and listed on the SEHK by direct IPO or by acquiring a listed company to go public indirectly. In recent years, many non-government background companies are also incorporated in this way and listed their shares on SEHK, such as China Mobile (Hong Kong) and Levono. These companies are also called Red Chips. By the end of 2004, 81 Red Chip companies have been listed on the Main Board of SEHK and its market capitalization is 21.26% of the total market capitalization of the Main Board.

Similar to the Red Chips in SEHK, a number of Chinese firms have registered a listing vehicle and listed on NASDAQ, Singapore, Toronto, and Australia stock exchange. Since the listing entities registered in different places and listed with different methods, there are no accurate statistics.

The records of official overseas listings in China Securities and Regulatory Commission (CSRC) began in 1993, when Tshingtao Brewery first listed on SEHK as H share. Since then, a number of large state-owned enterprises, such as SINOPEC and Huangneng Power, have entered the stage of the international equity market. They were featured as the market leaders of each industry in China and were selected to list overseas for their economic importance, management quality, technology, profitability and international significance. At the same time a number of companies are selected to list on New York Stock Exchange in the form of American Depository

Receipts. According to the statistics from CSRC, by the end of Nov. 2004, there are 107 companies listed overseas, of which 106 have issued shares in the SEHK.

3.2 Methods of overseas listing

There are two common methods for Chinese firms to list abroad. One is direct listing, the other is indirect listing.

Direct listing is to list the share of a company directly on foreign exchange, such as IPO, ADRs and GDRs. The direct listing is subject to the regulation of China Securities Regulatory Commission. It requires the approval from CSRC three month before the application to foreign exchanges. It usually takes more than one year from the preparation to the final listing. The approval for further financing, such as the placement, is stricter and takes more time.

Indirect listing is to form a listing vehicle in a foreign jurisdiction, usually a "tax haven", through a corporate restructuring. Thereafter, the listing vehicle is listed on a foreign stock exchange. A Foreign Vehicle Listing still needs to be approved by the CSRC if the listing vehicle is owned by Chinese shareholders. However the regulation is much more lenient than the direct listing. For example, the placement within 20% of existing equity only requires the approval from the board of the company. For those private-owned or hi-tech firms which need financing urgently, they can avoid the approval from CSRC by consolidating themselves under the control of an off-shore holding company, and this company is not controlled by Chinese shareholders. The indirect listing method could also break

down into two ways. One is the direct listing of foreign vehicle, and the other is through the acquisition of a listed firm and to get the 70- 90 percent shares of that firm.

3.3 The motivation for Chinese firms to list overseas

The international listing of Chinese companies is different from its counterparts, in that most of the non-Chinese companies have already issued shares in their domestic equity market before they list their shares on a foreign exchange, while none of the Chinese firms has issued shares in the home stock market before the international listing. By the end of 2003, there are 29 firms cross-listed on the domestic exchanges and the SEHK, all of which have issued H shares prior to their A share's listings.[2] The different sequence of the listing indicates that there are different motivations for Chinese companies to list abroad.

According to a survey of Canadian corporate managers, the motivation and the main benefits of international listing are to access a broader investor base and to increase the marketability of a firm's securities. However, the first and foremost motivation of the Chinese companies' overseas listing is to raise a large amount long term capital for future growth. Although the Chinese equity market has developed

[2] ZTE Corporation is the first Chinese firm which H share listing (Sep. 9, 2004) is later than it's A share listing (Nov. 18, 1997).

rapidly in the past 10 years, it cannot satisfy the great demand of capital. Owing to the premature nature of the Chinese stock market, there is a fear that the equity market will collapse if too much capital is to be raised domestically. For this reason, a number of big Chinese enterprises have chosen to go abroad.

The second motivation of overseas listing is to improve the corporate governance of the large state-owned enterprises. Although overseas listing can obtain a large amount of long-term capital, it is not cheap. The listing companies have to pay for an underwriting fee to the investment bank, a first time listing fee and an annual fee to the stock exchanges, which make the public offering become the most expensive way to raise the capital. In spite of the expensive cost, and the stricter requirement of disclosure compared with the China equity market, some of the Chinese companies still chose to list abroad. Compliance with these requirements enables the listing firms to establish a good corporate structure and modern corporate governance. In fact, the early large state-owned enterprises' overseas listings were prompted by the government on this concern.

The third motivation is to build an international image and gain visibility in the global market. Raising capital from the global equity market is a necessary step for firms to expand their business overseas. Information disclosure and analyst coverage accompanied by a listing will make the firms better known by potential

foreign partners and customers. For instance, Air China chose to list shares on the London Stock Exchange in addition to the Stock Exchange of Hong Kong in a recent overseas public offering because the company's international business focuses in Europe.

Finally, for private firms who need the capital urgently for development, foreign listing on the U.S. Nasdaq and HK GEM etc. is a quicker way to access the capital. Before the 2004, there is no secondary board like Nasdaq and GEM in Mainland China, and the high-tech private firms are usually not qualified for listing on Shanghai and Shenzhen exchanges. In addition, the capacity of the China equity market is limited. Even they are eligible to listing, an approval from the CSRC is required first. It usually takes more than one year from application for listing approval to finally going public. However, overseas listing could be completed within half a year through the indirect listing on less stringent exchanges, which could satisfy the urgent capital needs of these firms.

3.4 The prospects of China Overseas listing

We believe there are three trends for Chinese firms to list overseas.

Firstly, large state-owned enterprises will continue to list on important international exchanges with strict requirements, such as the NYSE and SEHK. The

capacity of the China equity market is expected to expand in the future but the expansion pace will be under the control of the government to prevent any negative impact on the domestic equity market. Thus, the overseas listing will continue to be the main source for large enterprises to raise capital. Besides, the Chinese government will encourage large state-owned enterprises to list on foreign exchanges as usual so that they can improve their management and play a greater role in the global competition.

Secondly, a number of firms which has listed overseas will finally list on the China equity market in the next three to five years. At present, 106 firms have issued H share in SEHK, but only 29 have issued A share in the domestic market. Since the P/E ratio of A share market is relatively higher than that of Hong Kong market, there are motivations for these companies to list on the home market to access the relatively cheaper capital. In addition, since the firms listed abroad are usually of higher quality and have a reliable growth prospects, such as PetroChina Company Limited, they are welcomed by both private investors and the government. Their listings could hopefully improve the quality of the Mainland equity market and let the general public share their profits.

Finally, for private-owned high-tech firms, there is another choice in domestic market- the Shenzhen secondary board. However, we believe in the next 3 to 5 years,

the foreign listing will still be their first choice for two reasons. First, the mature and established foreign exchanges will facilitate the capital raising and valuation of the firm. Second, listing on Nasdaq and etc. could quickly make the firm known to both domestic and foreign investors, and thus increase the visibility and enhance the ability to raise more capital.

Chapter 4. Price-discovery contributions to China-backed stocks cross-listed on SEHK and NYSE

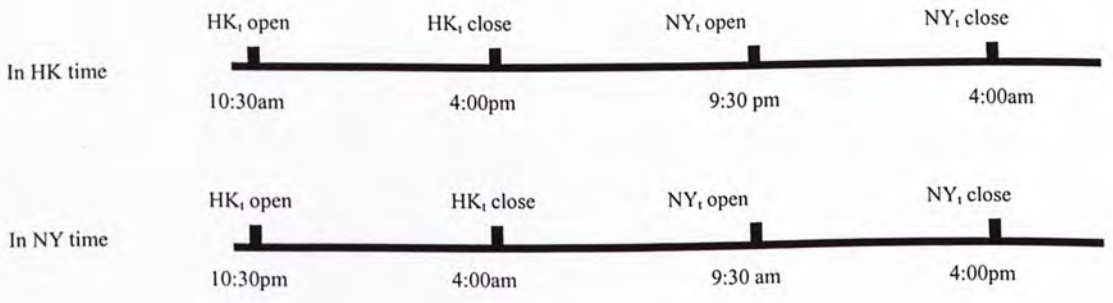
Since the early 1990s, Chinese state-owned enterprises have begun to list their securities overseas. The early overseas listings were prompted by the Chinese government on the concern of improving corporate governance of large SOEs by complying with stricter financial reporting standards of foreign exchange as well as enhancing an international image. In recent years, more and more companies chose to list overseas to access capital. According to the statistics of China Securities Regulatory Commission, by the end of Nov. 2004, there are 17 Chinese firms listed on New York Stock Exchange (NYSE), five on London Stock Exchange, one on the Stock Exchange of Singapore, and 106 on the Stock Exchange of Hong Kong. Some of the Chinese firms listed on more than one overseas exchange, and the majority of these firms are cross-listed on SEHK and NYSE. In this chapter, we investigate the relative contribution of SEHK and NYSE to the price-discovery process for cross-listed China-backed stocks.

4.1 Data

Previous researches on price discovery across the developed countries (Eun and Sabherwal, 2003; Grammig, Melvin and Schlag, 2005; Hupperets and Menkveld,

2000; Pascual, Pascual-Fuster and Climent, 2001; Ding et al., 1999) use high frequency data to ensure the simultaneity of observed price across markets. These studies can be done because there is an overlapping trading period between the two markets and the high frequency data is available. Due to the lack of high frequency data, Kadapakkam, Misra, and Tse (2003) use daily data to examine the contribution of Indian GDRs to the underlying stocks listed on Munbai. With enough long period of data, they find that London market contributes nearly 50% of Indian stocks. In our study, we use daily data since there are no overlapping trading hours between the NYSE and SEHK. Figure 1 presents the relative timing of trading hours of the NYSE and SEHK. Hong Kong standard time is 12 hours ahead of New York. SEHK begins trading at 10:00am and closes at 4:00pm in local time. NYSE's trading hour is from 9:30am to 4:00pm in local time, which is 9:30 pm to 4:00am in Hong Kong time. Therefore, there are no overlapping trading hours.

Figure 1. Trading Hours of SEHK and NYSE



There are totally 12 Chinese firms cross-listed on SEHK and NYSE at the end of 2004. We exclude the firms whose listing was later than Dec. 31, 1998 in either market to ensure that the sampling period is at least 5 years. The sample size is reduced to eight firms after we impose this restriction. The basic information of these eight firms is reported in Table 4.1.

We obtain the daily closing prices of these cross-listed Chinese stocks from the Datastream. Each firm's data period starts from the later listing date on the two exchanges to Nov. 30, 2004. We also collected the daily exchange rate of U.S. dollar to HK dollar from the database of the U.S. Federal Reserve. Using the exchange rates and the conversion ratios (number of Hong Kong shares that is equivalent to one share of ADRs), we convert the ADRs price to Hong Kong dollar price per share so that the ADRs price and Hong Kong price are directly comparable.

4.2 Methodology

We will use two popular common factor models to investigate the mechanics of price discovery: the permanent-transitory (PT) model of Gonzalo and Granger (1995) and the information shares (IS) model of Hasbrouck (1995). Both models use vector error correction model (VECM) as their basis. However they provide different

views on the price-discovery process. The PT model of Gonzalo and Granger (1995) focuses on the error correction process. The process involves permanent and transitory shocks to prices where only the permanent shock results in the disequilibrium of the prices. This disequilibrium occurs because the markets process news at different rates. The PT model measures each market's contribution to this common factor and the contribution is the function of the markets' error correction coefficients. The IS model of Hasbrouck (1995) defines price discovery in terms of the variance of innovations to the common factor. Thus the IS model measures each market's relative contribution to this variance. This contribution is named market's information share.

4.2.1 Permanent-Transitory model

Consider two cointegrated I(1) price series, $P_t = (P_{1t}, P_{2t})'$. A vector error correction model can be estimated as:

$$\Delta P_t = \alpha \cdot \beta' P_{t-1} + \sum_{j=1}^{k} A_j \Delta P_{t-j} + e_t , \qquad (1)$$

where α is an error correction vector, β is a cointegrating vector and e_t is a zero-mean vector of serially uncorrelated innovations with covariance matrix Ω such that:

$$\Omega = \begin{pmatrix} \sigma_1^2 & \rho\sigma_1\sigma_2 \\ \rho\sigma_1\sigma_2 & \sigma_2^2 \end{pmatrix} . \qquad (1a)$$

σ_1^2 (σ_2^2) is the variance of e_{1t} (e_{2t}) and ρ is the correlation between e_{1t} and e_{2t}. The VECM has two portions: the first portion, $\alpha \cdot \beta' P_{t-1}$, represents the long-run equilibrium dynamics between the price series; and the second portion, $\sum_{j=1}^{k} A_j \Delta P_{t-j}$, depicts the short-run dynamics induced by market imperfections.

It is similar to Stock and Watson's (1988) common trend representation:

$$Y_t = f_t + G_t \quad , \qquad (2)$$

where f_t is the common factor component and G_t is the transitory component that does not have a permanent impact on Y_t. Gonzalo and Granger (1995) define the common factor to be a combination of the variables $Y_t = (y_{1t}, y_{2t})$, such that $f_t = \Gamma Y_t$, where $\Gamma = (\gamma_1, \gamma_2)$ is a 1×2 common factor coefficient vector. They show that Γ is orthogonal to the error correction coefficient vector α, denoted by $\Gamma = \alpha_\perp'$. Γ is normalized so that $\Sigma\gamma_i=1$. The specification f_t can be considered equivalently to a portfolio of prices from each market with Γ serving as the portfolio weights (Harris, McInish and Wood, 2002a). Therefore, the contribution of the first (second) market to the price discovery could be measured by $\gamma_1(\gamma_2)$.

4.2.2 Information Share model

Hasbrouck (1995) transformed Eq. (1) into a vector moving average (VMA)

form:

$$\Delta P_t = \psi(L)e_t \quad , \qquad (3)$$

its integrated form is:

$$P_t = \iota\psi\left(\sum_{s=1}^{t} e_s\right) + \psi^*(L)e_t \quad , \qquad (4)$$

where $\iota = (1,1)'$ is a column vector of ones, $\psi = (\psi_1, \psi_2)$ is a row vector, and $\psi^*(L)$ is matrix polynomials in the lag operator, L.

Hasbrouck (1995) shows that Eq.(4) is closely related to Eq.(2). Hasbrouck (1995) states that the increment ψe_t from the first part of Eq.(4) is the component of price change that is permanently impounded into the price and is presumably due to new information. Not included in this impact is the transient effect, which is $\psi^*(L)e_t$ in Eq.(4). Hasbrouck defines this component to be the common efficient price (common factor) between the two prices. He decomposes the variance of the common factor innovations, $\text{var}(\psi e_t) = \psi\Omega\psi'$, therefore the information share of a market is the proportion of var(ψe_t) that can be attributable to innovations in that market. Hasbrouck argues that if covariance matrix Ω is diagonal, the information share of the market j is given by:

$$S_j = \frac{\psi_j^2 \sigma_j^2}{\psi \Omega \psi'} \quad , \qquad (5)$$

where ψ_j is the j th element of ψ. If Ω is not diagonal (i.e., the residuals are

contemporaneously correlated), the information share is not exactly identified.

Baillie, Booth, Tse, and Zabotina (2002) examine the relationship between the PT and IS model and prove that $\frac{\psi_1}{\psi_2} = \frac{\gamma_1}{\gamma_2}$. Therefore, if there is no correlation between the error terms, the information share can be computed directly from

$$S_j = \frac{\gamma_j^2 \sigma_j^2}{\gamma_1^2 \sigma_1^2 + \gamma_2^2 \sigma_2^2}, \quad \text{and} \tag{6}$$

$$\frac{S_1}{S_2} = \frac{\gamma_1^2 \sigma_1^2}{\gamma_2^2 \sigma_2^2}. \tag{7}$$

However, if the price innovations are significantly correlated across markets, Eq.(6) does not hold. Hasbrouck (1995) uses the Cholesky factorization of $\Omega = MM'$ to eliminate the contemporaneous correlation, where M is a lower triangular matrix. The information share is given as follows:

$$S_j = \frac{\left([\psi M]_j\right)^2}{\psi \Omega \psi'}, \tag{8}$$

where $[\psi M]_j$ is the jth element of the row of matrix ψM. Denote

$$M = \begin{pmatrix} m_{11} & 0 \\ m_{12} & m_{22} \end{pmatrix} = \begin{pmatrix} \sigma_1 & 0 \\ \rho\sigma_2 & \sigma_2(1-\rho^2)^{1/2} \end{pmatrix}. \tag{9}$$

Baillie, Booth, Tse, and Zabotina (2002) derive that,

$$\frac{S_1}{S_2} = \frac{\left(\gamma_1 m_{11} + \gamma_2 m_{12}\right)^2}{\left(\gamma_2 m_{22}\right)^2}. \tag{10}$$

Since $S_1 + S_2 = 1$,

$$S_1 = \frac{(\gamma_1 m_{11} + \gamma_2 m_{12})^2}{(\gamma_1 m_{11} + \gamma_2 m_{12})^2 + (\gamma_2 m_{22})^2} \quad , \quad \text{and} \qquad (11)$$

$$S_2 = \frac{(\gamma_2 m_{22})^2}{(\gamma_1 m_{11} + \gamma_2 m_{12})^2 + (\gamma_2 m_{22})^2} \quad . \qquad (12)$$

Eq.(11) and Eq.(12) show that information share only depends on α from Eq.(1) (or its orthogonal of $\Gamma=(\gamma_1,\gamma_2)$) and Ω. They also show that the factorization imposes a greater information share on the first price, unless $m_{12} = 0$ (i.e., no correlation between market innovations). Hasbrouck (1995) considers the upper (lower) bound of market j's information share when market j is the first (second) variable in the factorization. Moreover, Eq.(11) and Eq.(12) show that the higher correlation, the greater (smaller) the upper (lower) bound. In Hasbrouck's (1995) study, he uses one-second interval of prevailing quotes, and reports that upper bounds and lower bounds are almost the same. Booth, Lin, Martikainen and Tse (2002) use trading intervals averaging approximately 30 minutes and report an average of 99.2% for upper bound and 13% for lower bound of the information share. For a bivariate case, Baillie, Booth, Tse, and Zabotina (2002) show that the average of the lower and upper bounds is a reasonable estimate of a market's contribution in price discovery.

In our study, we will follow Baillie, Booth, Tse, and Zabotina (2002) to compute the information share of Hasbrouck's (1995) model. After getting the error correction coefficient vector of $\alpha=(\alpha_1,\alpha_2)$, and its orthogonal vector $\Gamma = (\gamma_1, \gamma_2)$, the

covariance matrix of the error terms will be computed. If the correlation coefficient of the error terms is significantly different from zero, Cholesky factorization of Ω will be computed to get the information share with Eq.(11) and Eq.(12). Since this method imposes a greater information share on the first price, both upper bound and lower bound of each price will be calculated and the average of these two bounds is to be reported as information share.

4.3 Empirical Results and Interpretation

With the difference in the time zone, the daily closing price in SEHK in date t is 12 hours earlier than NYSE in date t, and the daily closing price in SEHK in date t is 12 hours later than NYSE in date (t-1). Because there is a 12-hour period between the closing prices of two markets, and it is likely that a later closing price will incorporate more information and thus contribute more to the price discovery, different pairings of the closing price is necessary in examining the contribution to the price discovery of each market. In our study, we examine both pairs, (P_t^{HK}, P_t^{NY}) and (P_t^{HK}, P_{t-1}^{NY}), where P_t^{HK} is the closing price in SEHK in day t, and P_t^{NY} is the closing price in NYSE in day t.

4.3.1 Conintegration test

When two time series, for example x_t and y_t, are nonstationary and integrated of the same order, denoted as I(n), but their linear combination, $z_t = y_t - Ax_t$, are integrated of order m, denoted as I(m), where m<n, they are said to be cointegrated. In the case of the stock price series, they are usually random walk process, which is I(1) process, and they are said to be cointegrated if their linear combination is I(0), which is a stationary process. Therefore, in order to test whether or not the price in SEHK and the price in NYSE are cointegrated, we will first check whether the two price series for each stock are I(1) process.

A. Unit root test

We use Augmented Dickey-Fuller (1981) test to check for the presence of a unit root. For each price series, we estimate the following three regression equations.

$$\Delta P_t = \gamma P_{t-1} + \sum_{t=1}^{p} \phi_i \Delta P_{t-i} + e_t \qquad (13)$$

$$\Delta P_t = c_0 + \gamma P_{t-1} + \sum_{t=1}^{p} \phi_i \Delta P_{t-i} + e_t \qquad (14)$$

$$\Delta P_t = c_0 + \gamma P_{t-1} + c_1 t + \sum_{t=1}^{p} \phi_i \Delta P_{t-i} + e_t \qquad (15)$$

The null hypothesis in all three equations is that $\gamma = 0$. If the null hypothesis cannot be rejected, the P_t series contains a unit root. Schwarz Bayesian Criterion (SBC) will be used to determine p, which is the number of lags in the model. The critical value of the t-statistic, given by Enders (1995), depends on the equation being estimated. The critical value at the 5% significance level is -1.95 for Eq.(13), the

critical value at the 5% significance level is -2.86 for Eq.(14), and the critical value at the 5% significance level is -3.41 for Eq.(15).

The results of Augmented Dickey-Fuller unit root test are reported in Table 4.2. Using the critical values provided by Enders (1995), we find that at the 5% significance level, the null cannot be rejected for the seven out of eight companies in all the three cases. For China Southern Airline (ZNH), the null hypothesis is rejected for Eq.(14) and Eq.(15) for prices both on SEHK and NYSE. Therefore both price series of China Southern Airline are pure random walk process without a constant or a time trend. Overall, we conclude that both price series for each stock are I(1) process.

B. Cointegration test and error correction model

Since the price series in SEHK and NYSE are I(1) processes, we can now check whether (P_t^{HK}, P_t^{NY}) and (P_t^{HK}, P_{t-1}^{NY}) are cointegrated of order 1, that is CI(1,1). Engle and Granger (1987) propose a straightforward method. If y_t and x_t are CI(1,1), there exists a cointegrating vector $(1, -\beta_1)$ such that the linear combination of y_t and x_t is a stationary process. The steps are as follows:

Firstly, we test if the two variables are integrated of order 1 using the unit root test. We have done it already.

Secondly, we estimate a long-run equilibrium relationship between the two

variables by the following equations:

$$P_t^{HK} = \beta_0 + \beta_1 P_t^{NY} + e_t \qquad (16)$$

$$P_t^{HK} = \beta_0 + \beta_1 P_{t-1}^{NY} + e_t \qquad (17)$$

Denote the residual sequence from above by $\{\hat{e}_t\}$. If the estimated residuals series $\{\hat{e}_t\}$ is found to be stationary, then the two series are CI(1,1).

Thirdly, we check whether the residual series is a stationary process. A unit root test will be performed on the estimated residual series.

$$\Delta\hat{e}_t = a_1\hat{e}_{t-1} + \varepsilon_t \quad . \qquad (18)$$

In the regression equation we estimated, there is neither a constant nor a linear trend presented. This is because $\{\hat{e}_t\}$ series is the estimated residuals from the regression, and we expect them to be a white noise with a zero mean. The null hypothesis is that a_1 is zero. If the null hypothesis is rejected, we conclude that $\{\hat{e}_t\}$ series does not contain a unit root, which implies that the residual series is stationary. Since the $\{\hat{e}_t\}$ series is the estimated residuals from the regression equation, Dickey-Fuller table cannot be used to examine the significance of the t-statistic. The critical values for t-statistics are provided by Engle-Yoo (1987). With 2 variables and a sample size of 500, the critical values at the 1% and 5% significance levels are: -3.92 and -3.35. The Engle-Granger (1987) test results are reported in Table 4.3. For all the eight Chinese companies, the estimated coefficients of β_1 for the two pairs

of price series, (P_t^{HK}, P_t^{NY}) and (P_t^{HK}, P_{t-1}^{NY}), are significant at the 1% level. The magnitude of β_1 is within the range of (0.990, 1.005). We test the null hypothesis, H_0: $\beta_1=1$, for each pair of price series. The null cannot be rejected at the 5% level for both pairs of prices. This suggests that there is no persistent price difference between the shares listed on SEHK and NYSE for these eight stocks. The estimated coefficient of a_1 is statistically significant at 1% for both pairs of each company. Therefore, the null hypothesis that $a_1 =0$ is rejected at the 1% level, which implies that the estimated residual series are stationary. From Table 4.3, we conclude that the two pairs of price series for all companies are cointegrated at the 1% significance level.[3]

Since the two pairs of prices are cointegrated, an error correction model can be estimated as suggested by Engle and Granger (1987). As the residual $\hat{e}_t$ estimates the deviation from the long-run equilibrium in period t, we can use the saved residuals $\{\hat{e}_t\}$ as a proxy for $P_t^{HK} - \beta_1 P_t^{NY}$. Thus, using the saved residuals from the estimation of long-run equilibrium relationship, we can estimate the error-correction model as:

$$\Delta P_t^{HK} = \alpha_0^{HK} + \alpha_1^{HK}\hat{e}_{t-1} + \sum_{i=1}^{p}\gamma_i \Delta P_{t-i}^{HK} + \sum_{i=1}^{p}\delta_i \Delta P_{t-i}^{NY} + \varepsilon_t^{HK} \qquad (19)$$

[3] We use Johansen method to test the cointegration between (P_t^{HK}, P_{t-1}^{NY}) and (P_t^{HK}, P_t^{NY}), and get the same result.

$$\Delta P_t^{NY} = \alpha_0^{NY} + \alpha_1^{NY}\hat{e}_{t-1} + \sum_{i=1}^{p}\gamma_i \Delta P_{t-i}^{HK} + \sum_{i=1}^{p}\delta_i \Delta P_{t-i}^{NY} + \varepsilon_t^{NY} \qquad (20)$$

The estimated error correction coefficient $(\alpha_1^{HK}, \alpha_1^{NY})$ is the main concern of our studies. We report the error correction coefficient that is significant at the 5% significance level. For those that are not significant, they will be substituted by zero. The estimated error correction coefficient is reported in Table 4.4.

4.3.2 Price-discovery contributions

We compute the price-discovery contribution for each market with PT and IS models, which illustrated in Methodology, and report the result in Table 4.5 and Table 4.6. Table 4.5 presents the common factor coefficients of PT model and information share of IS model of the pair of prices (P_t^{HK}, P_t^{NY}). From Table 4.5, we could see that the average common factor coefficient vector Γ= (0.274, 0.726). Except for Guangshen Railway Co., whose common factor coefficient of P_t^{HK} is slightly larger than that of P_t^{NY}, all the other seven firms' price-discovery contributions of the NYSE measured in common factor coefficients, are larger than SEHK. Overall, this suggests that the NYSE (72.6%) contributes more than SEHK (27.4%) to the price-discovery process in the same trading day. We also use the average information shares to summarize the results and report them in Table 4.5. Similar to the common factor coefficients, except for Guangshen Railway, all the other

cross-listed firms have a larger share of price-discovery contribution from the NYSE. On average, the information share of NYSE (61.6%) is more than that of SEHK (38.4%). Thus, based on the closing price of the same trading day, both Gonzalo and Granger (1995) and Hasbrouck (1995) models show that NYSE makes a larger contribution than SEHK to the price discovery for these China Stocks cross-listed on both exchanges. Since NYSE closing price is about 12 hours later than SEHK closing price, a larger share of contribution made by NYSE is possibly because it incorporates more information.

We report the price-discovery contribution result for another pair of prices in Table 4.6. In this case, we pair the SEHK closing price in date t with NYSE closing price in date t-1. In this pair, the SEHK closing price is 12 hours later than NYSE previous day closing price. For all eight cross-listed stocks, SEHK contributes substantially to the price-discovery process. The average contribution of SEHK increase to 81.6% and 89.4%, and the average contribution of NYSE drop to 18.4% and 10.6% respectively. Compared with Table 4.5, the average contributions of NYSE 12-hour late closing price, which are 72.6% and 61.6%, are smaller than SEHK 12-hour late closing price, which are 81.6% and 89.4%. Combining the Table 4.5 and Table 4.6, the average common factor coefficients are (0.547, 0.453), and the average information shares are (0.662, 0.338), which suggest a greater price-discovery

contribution from the SEHK.

Since two firms, China Mobile and Sinopec Beijng Yanhua, do not issue shares in China stock market, we exclude them and examine each market's contribution again. The contributions of SEHK and NYSE now become (0.366, 0.634) for PT model and (0.437, 0.563) for IS model for the first pair of prices (P_t^{HK}, P_t^{NY}). The contributions of SEHK and NYSE become (0.863, 0.137) and (0.944 0.056) for the second pair (P_t^{HK}, P_{t-1}^{NY}). The average contribution is (0.615, 0.385) and (0.691, 0.309) for PT model and IS model respectively. For these six stocks which have issued shares in China equity market, the results suggest that the SEHK plays a more important role in finding the implicit efficient price. The results taken together suggest that for cross-listed China-backed stocks, SEHK contributes more to the price-discovery process, and the NYSE's contribution is not negligible.

Compared with NYSE market, SEHK contributes more to the price discovery of Chinese cross-listed stocks. There are two possible reasons:

Firstly, due to the close economic relationship, linguistic and geographical proximity between China and Hong Kong, Hong Kong is more like a domestic market of China. In Xu and Fung's (2002) study of information flow between SEHK and NYSE of a number of China-backed stocks cross-listing on two markets, they deem the Hong Kong market to be the home market in their analysis.

Secondly, Hong Kong market and China market are in the same time zone. Since important information is likely to be released in the day time of the company's headquarter, the closing price of HK market is likely to incorporate more valuable information than the closing price of U.S. market. That explains why 12-hour lagged SEHK closing prices contribute substantially to the price-discovery process.

If we consider the Hong Kong market to be the domestic market compared with NYSE, our result is similar to Lieberman, Ben-Zion and Hauser's (1999) study. In their study, they also use daily closing price and find that Israeli market has stronger influence on share prices in the U.S. Kadapakkam, Misra and Tse's (2003) find that for cross-listed Indian stocks, London and Mumbai market contributes almost equally to the price-discovery process. Our results suggest that SEHK contributes substantially more to the price-discovery process.[4] However, NYSE also plays an important role in the price discovery, since the common factor coefficient and information share for NYSE are 18.4% and 10.6% when HK prices are 12-hour late and incorporate more information.

4. 4 Cross-Sectional analysis of NYSE contributions to the price-discovery process

[4] We pair the SEHK closing price with NYSE open price, as well as SEHK open price with NYSE previous day closing price to examine the price discovery contribution. We find that the in these two quasi-simultaneous pairs, HK market also contributes more to the price discovery process except for China Mobile (Hong Kong).

We have seen that the NYSE has variant contributions to the cross-listed Chinese stocks. To further investigate the NYSE's role in the price discovery, we examine in this subsection what could possibly determine the magnitude of NYSE contribution. We run a regression with the following variables:

A. Dependent Variable

The contribution of NYSE is measured by the common factor coefficient γ_N and the information share I_N. We have examined two pair of price series: (P_t^{HK}, P_t^{NY}) and (P_t^{HK}, P_{t-1}^{NY}), and find that the contribution of NYSE calculated by Gonzalo-Granger Permanent-transitory model and Hasbrouck information share model are affected by the choice of the pairs, that is one market contributes more to the price-discovery process if its closing price comes later. Therefore, we compute γ_N by taking the average of common factor coefficients of NYSE, and compute I_N as the average of information share of NYSE from both pairs as the measurement of NYSE price-discovery contribution.

B. Explanatory Variable

B. 1. NYSE share of trading volume (Nvol)

Hasbrouck (1995) finds a positive and statistically significant correlation between the NYSE contribution and its market share of trading volume in a study of 30 dually-listed Dow stocks. Eun and Sabherwal (2003) also find that the

price-discovery contribution of U.S. markets to the cross-listed Canadian stocks is significantly correlated with U.S. share of trading volume. Daily trading volume is a measure of liquidity, and a high liquidity will attract more informed traders. Therefore, we expect the NYSE share of trading volume to be positively related to NYSE information share and common factor coefficient. We use the ratio of average daily trading volume of the cross-listed stock in NYSE to that of SEHK as a proxy for NYSE share of trading, since the NYSE trading volume is much smaller relative to SEHK daily trading volume[5].

B. 2. Initial ADRs Size (ADRSIZE)

The higher the number of analysts pays attention to a stock, the more quickly the information will be reflected in the stock price. We expect NYSE contribution to be positively related to the analyst coverage of the stock. However, since the analyst coverage is not available directly for these Chinese stocks, we use the initial ADRs size as a proxy. The larger the initial ADRs size, the more analysts will cover this stock. Therefore we expect a positive relationship between the NYSE contribution and the initial ADRs size.

B. 3. Listing on China stock exchanges (Lcn)

[5] In Eun and Sabherwal's (2003) study, they use the U.S. share of trading volume, which is the U.S. trading volume divided by the total trading volume of both Canadian and U.S. markets.

We include a dummy variable Lcn as a proxy for the listing on the Chinese stock exchanges. The international listings of Chinese enterprises are quite different from the companies of other countries in that the firms were usually listed first on an overseas exchange before they got listed in the domestic equity market. By the end of 2003, only 29 firms have issued A share in home market after they issued shares in foreign exchanges. For China-backed stocks cross-listed on NYSE and SEHK, some of the firms also issued shares on China stock exchanges. We believe the listing on China stock market will enhance the relative price-discovery contribution of the SEHK. A number of previous studies show that the China equity market is weak-form efficient (Li, 2003; Lima & Tabak, 2004), which implies that the price does not reflect all public information. The investors can use public and private information to make profits and thus driving the price to implicit efficient value. Therefore some of the company-related information will be reflected first in the price of A share. Since the Hong Kong market is close to the China market and has nearly the same trading hours, compared with NYSE, the price in SEHK will move first to reflect the relevant information. We believe the magnitude of NYSE contributions to China-backed stocks will be reduced if the firm has issued A share in the home market.

C. Regression Analysis

Since the sample includes only eight firms, not all explanatory variables could be included in the regression equations at the same time. Therefore, we include one explanatory variable each time in our analysis. We employ the following regression specifications:

$$\gamma_N \text{ or } I_N = c + p \cdot X_i \qquad (21a)$$

$$\gamma_N \text{ or } I_N = c + p \cdot X_i + q \cdot Lcn, \qquad (21b)$$

where c is constant, X_i is one of the variables of Nvol and ADRsize, Lcn is the dummy variable, and equals to 1 if the stock is listed in China. The regression results are reported in Table 4.7.

We expect that the share of NYSE average daily trading volume, and the ADRs size should be positively related to the price-discovery contribution of NYSE for these eight stocks. However, the coefficient of p is statistically insignificant if the dummy variable is not included. Overall, the regression results do not support our hypothesis.

If we compare the adjusted R^2 before and after the dummy is included, we could see that the adjusted R^2 increases substantially after the dummy of the listing on China (Lcn) is included. Actually, the dummy variable is statistically significant in all the 4 regressions with the dummy variable. This suggests that the NYSE

contributes less in the price-discovery process if the stock is listed on the Chinese exchanges compared to those that are not. In another expression, for stocks which have issued shares in the China market, SEHK contributes more to the price-discovery process. The results support our original hypothesis.

In this chapter, we study eight China-back stocks cross-listed on SEHK and NYSE. We find that the daily closing prices of the same stock on two exchanges are cointegrated with a cointegrating vector of (1, -1). The common factor coefficient and information share computed from PT model and IS model suggest that the SEHK makes more contribution to the price-discovery process than the NYSE, and the results support Xu and Feng's (2002) study. In the cross-sectional analysis, we find that NYSE's price-discovery contribution is negatively related to a listing on the China stock market, which suggest that the SEHK contributes more to stocks which are listed on the China stock market.

Chapter 5. Price-discovery contributions to the cross-listed H share and A share

H share companies refer to the Chinese companies which are incorporated in mainland China and listed on Hong Kong. Compared with Red Chip companies, which are incorporated outside China and listed on SEHK, H share companies have more concentrated business and simpler company structure. In 1993, the first H share Tsingtao Brewery listed on SEHK. Since then, a lot of large stated-owned enterprises have listed their shares in Hong Kong stock market. By the end of Nov. 2003, 106 firms have issued H share in SEHK Main Board and Growth Enterprise Market.

The early H share listings were prompted by the Chinese government to improve the corporate governance, establish a modern company structure as well as enhance the global image of Chinese large state-owned enterprises. Hong Kong is chosen for her role as the financial center in Asia-Pacific as well as its geographical and language proximity to China.

Among the 106 H share companies, 29 have issued A share in Shanghai or Shenzhen stock exchange. The companies' information is reported in Table 5.1. For these cross-listed H share and A share, in which market the price-discovery process mainly occurs? Previous studies document that the price discovery mainly

occurs in the home market, since it is the place where the information of the cross-listed stocks is released first. In our research of the Chinese stocks cross-listed on SEHK and NYSE, both exchanges contribute to the price-discovery process, where SEHK plays a more important role in finding the implicit efficient price. Considering cross-listed H share and A share, whether SEHK contributes to the price-discovery process is worthy of investigation.

Most of previous studies (Eun and Sabherwal, 2003; Ding et al., 1999, etc.) on the price discovery of cross-listed stocks use intraday data to assure the simultaneity. Since the Chinese exchanges and SEHK are in the same time zone, and there is a two-hour overlapping period between two markets, it is possible to examine price-discovery contribution with high frequency intraday data.

5.1 Data and Sample details

A. Source of Data

The intraday data used in this chapter are from two resources. The data of H share are from the Trade Record, Main Board, which is published by the Stock Exchange of Hong Kong every month. It contains all equity trading price and volume for the day, sorted by the stock ID. The intraday data of A share are from China Stock Trade and Quote Research Data Base supplied by Guo Tai An

Information and Technology Co. Ltd. Since the exchange rate between HK dollar and China RMB is relatively stable due to their pegging with U.S dollar, we convert the H share price to China RMB prices with the daily exchange rate collected from the website of Pacific Exchange Rate Service, Sauder School of Business, the University of British Columbia.

Other data, such as the date of listing on China and Hong Kong, and the number of A shares and H shares outstanding are from the Datastream. The number of tradable A share is from finance.sina.com.cn.

B. Sample Details

The study with intraday data covers five-month period from July 2 to November 30, 2003. Both markets are recovering from the impact of SARS[6], and the government intervention to the stock market is relatively less during this period for the China stock market. Therefore stocks cross-listed on two markets should adjust to the market efficient price determined by the fundamental assets of firm. The five-month sample period has 98 to 99 trading days for each stock's A share and H share after excluding the non-trading days of both markets.

We select the firms which have issued both A share and H share with a

[6] Nippani and Washer (2004) study the leading stock index of 7 countries and find that SARS had no negative impact on the stock markets of these countries except for China and Vietnam.

minimum trading history of six months before the study period, and exclude the thinly traded stocks to ensure the sufficient observations for intraday analysis. We consider the thinly traded stocks as those with fewer than 4000 trades during the five-month study period, which are fewer than average 40 trades per day or 10 trades per hour either in the Chinese exchanges or SEHK. Our final sample consists of 22 firms, with 18 listed on Shanghai Stock Exchange and 4 listed on Shenzhen Exchange (Table 5.2). In our cointegration and error correction test, we include the price of market performance in our analysis. We use Tracker Fund (Exchange Traded Fund of Hang Seng Index) as a proxy for the market movement of the Hong Kong market.[7] Since there is no counterpart in China market, we use the logarithm of Shanghai A share index[8] as a proxy for China market movement.

C. Price Series

China and Hong Kong are in the same time zone. For each working day, the China stock market opens from 9:30am to 11:30am in the morning and from 1:00pm to 3:00pm in the afternoon; Hong Kong stock market opens from 10:00am to 12:30pm in the morning and 2:30pm to 4:00pm in the afternoon. Therefore there is

[7] We do not use the Hang Seng Index (HSI) since the high frequency data of HSI are not available.
[8] The magnitude of Shanghai A index is in thousands, while the price of A share, H share and the Tracker Fund is in tens. We use the logarithm of Shanghai A index to facilitate our computation and comparison.

a 2-hour overlapping trading interval between the two markets from 10:00am to 11:30am and 2:30pm to 3:00pm. The price series of H and A share are constructed by selecting the first transaction price in each market every 15 minutes from 10:00am to11:30am and from 2:30pm to 3:00pm, and the last transaction price before 11:30am and 3:00pm. Quoted prices are not used due to the unavailability of high frequency bid-ask quotes of H share. Although the use of transaction prices is likely to suffer from an autocorrelation problem due to infrequent trading, we can solve this problem by imposing the proper lags in our unit root and cointegration test.[9] Consequently there are 10 prices per day in each market for each stock. If the stock is not traded in one of the market on a particular day for firm-specific reasons, we also exclude the observation as well.

5.2 Methodology

The method we used here is similar to Chapter 4, except that we do not use the Gonzalo-Granger (1995) Permanent-Transitory model or the Hasbrouck (1995) Information Share model to compute each market's contribution to the price-discovery process. Instead, the error correction coefficient will be used directly to measure the price-discovery contribution. Since there is a large price

[9] Eun and Sabherwal (2003) use both transaction prices and quoted prices in their analysis and find that there is no difference in the result.

discount of H share compared with A share prices, and the movement of market will be incorporated in the error correction term, we do not expect the meaning of common factor coefficients and information shares computed from error correction coefficient to be the same as in Chapter 4.

A. Unit root test

Firstly, an Augmented Dickey-Fuller test will be performed to check whether the price series are I(1) process. Similar to Chapter 4, we perform the ADF test on the intraday price series of H share and A share for each firm as well as the price of Tracker Fund (HSI) and the log of Shanghai A index (SHA) to check for the presence of a unit root. For each price series, we estimate the following three regression equations which are the same as in Chapter 4.

$$\Delta P_t = \gamma P_{t-1} + \sum_{i=1}^{p} \phi_i \Delta P_{t-i} + e_t \quad , \qquad (13)$$

$$\Delta P_t = c_0 + \gamma P_{t-1} + \sum_{i=1}^{p} \phi_i \Delta P_{t-i} + e_t \quad , \qquad (14)$$

$$\Delta P_t = c_0 + \gamma P_{t-1} + c_1 t + \sum_{i=1}^{p} \phi_i \Delta P_{t-i} + e_t \quad . \qquad (15)$$

B. Engle Granger Cointegration test of H share and A share price

Having the result that H share and A share are I (1) processes, we could check whether the price series of H share and A share of each stock are cointegrated. First,

we check whether there is a cointegration relationship between the two price series without the HSI and SHA incorporated in the error correction term. A regression equation is estimated as follows:

$$P_t^H = \beta_0 + \beta_1 P_t^A + e_t, \qquad (22)$$

where P_t^H denotes the price of H share, P_t^A denotes the price of A share.

Then a unit root test is performed on the estimated residual series to check whether it is a stationary process. We estimate the following equation as in Chap.4:

$$\Delta\hat{e}_t = a_1\hat{e}_{t-1} + \varepsilon_t \ . \qquad (18)$$

The null hypothesis is $a_1=0$. If the null is rejected, we conclude that the estimated residual series does not contain a unit root, thus the H share and A share prices are cointegrated. Engle and Yoo (1987) provide the critical values for the t statistics. With 2 variables and a sample size more than 800, the critical values at the 1%, 5%, and 10% levels are 4.00, 3.37 and 3.02 respectively.

C. Cointegration test of H share and A share with HSI and SHA

Wang and Jiang (2004) find that A share returns are subject to the market-specific risk and the investor sentiment that are specific to the China stock market, while the H share returns are subject to the risk and investor sentiment in both Hong Kong and China. Therefore, it is necessary to incorporate the market

movement in the error correction term for considering the market-specific return and investor sentiment.

The cointegration test follows the Engle Granger method. The first step is to estimate a relationship between the prices of H share and A share with the price of Tracker Fund (HSI) and the log of Shanghai A Index (SHA). The regression equation is estimated as follows:

$$P_t^H = \beta_0 + \beta_1 P_t^A + \beta_2 P_t^{HSI} + \beta_3 P_t^{SHA} + e_t . \qquad (23)$$

The following step is to perform a unit root test on the estimated residual. The critical values for the t-statistics of Dickey Fuller test of residual series are provided by the Engle-Yoo (1987) table. With 4 variables and a sample size of more than 800, the critical values at the 1%, 5% and 10% levels are -4.68, -4.12 and -3.83 respectively.

D. Error Correction Model and price-discovery contribution

If the prices are cointegrated, we can use the Engle-Granger method to measure each market's adjustment to their equilibrium relationship. Similar to Chapter 4, the error correction model will be estimated as follows for two price series:

$$\Delta P_t^H = \alpha_0^H + \alpha_1^H \hat{e}_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta P_{t-i}^H + \sum_{i=1}^{p} \delta_i \Delta P_{t-i}^A + \varepsilon_t^H , \qquad (24)$$

$$\Delta P_t^A = \alpha_0^A + \alpha_1^A \hat{e}_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta P_{t-i}^H + \sum_{i=1}^{p} \delta_i \Delta P_{t-i}^A + \varepsilon_t^A, \qquad (25)$$

For four price series, the error correction model will be estimated as follows:

$$\Delta P_t^H = \alpha_0^H + \alpha_1^H \hat{e}_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta P_{t-i}^H + \sum_{i=1}^{p} \delta_i \Delta P_{t-i}^A + \nu_i \Delta P_{t-i}^{HSI} + \zeta_i \Delta P_{t-i}^{SHA} + \varepsilon_t^H \qquad (26)$$

$$\Delta P_t^A = \alpha_0^A + \alpha_1^A \hat{e}_{t-1} + \sum_{i=1}^{p} \gamma_i \Delta P_{t-i}^H + \sum_{i=1}^{p} \delta_i \Delta P_{t-i}^A + \nu_i \Delta P_{t-i}^{HSI} + \zeta_i \Delta P_{t-i}^{SHA} + \varepsilon_t^A \qquad (27)$$

The lagged first difference is incorporated to control for the possible autocorrelation, and p is determined by Schwartz Bayesian Criterion (SBC). In the error correction models we estimated, the coefficient of α_1^H and α_1^A are of the main interest. If α_1^A (α_1^H) is significantly different from zero, the prices of A share (H share) adjust to the deviation from the equilibrium relationship among the H share, A share, HSI, and SHA. Since information should always be disclosed first in the home market, we expect the H share prices adjusts to the A share prices, which implies that α_1^H should be significantly different from zero. If α_1^A is also significantly different from zero, we expect the magnitude of α_1^H to be larger than α_1^A.

5.3 Empirical results and interpretation

The empirical results of the unit root test for each intraday price series are reported in Table 5.3. The null hypothesis is $\gamma=0$. If the t-statistic is not significant at the 5% level, we do not reject the null, which means that the price series contains a

unit root. Using the critical values provided by Enders (1995), we find that at the 5% level, the null cannot be rejected for all price series in Eq.(13). The null is rejected for four price series in Eq.(14) and one in Eq.(15) at the 5% significance level. Overall, we conclude that both prices series for the sample stocks, HSI and SHA are I(1) process.

We use the Engle-Granger cointegration test on the intraday price series of H share and A share. With proper lags chosen by SBC, at the 5% significance level, only three cross-listed stocks, Guangzhou Shipyard International Co Ltd (HK Code: 317), Shenzhen Expressway Co Ltd (HK Code: 548) and China Eastern Airline (HK Code.: 670), show cointegration relationships between their A share prices and H share prices. The results are not reported here.

The results of Engle-Granger cointegration test on 4 price series, with HSI and SHA included, are reported in Table 5.4. From this table, we could see that six firms' four price series are cointegrated at the 5% significance level, and 2 firms' four series are cointegrated at the 10% significance level.

In our study period from July 2 to Nov 30, 2003, both markets are recovering from the impact of SARS. There is little intervention on the economy from the China government. In addition, the Chinese equity market is more developed and established compared with the early 1990s. Therefore, we expect the price series of

cross-listed H share and A share to be cointegrated with each other in the intraday level. However, the empirical results suggest that there are only a few cross-listed stocks showing the cointegration relationship. For most of the stocks, there is no equilibrium relationship between the H share price and A share price at an intraday level and the two prices of the same stock move away from each other without bound even considering the respective market movement. The cointegration tests show that the Hong Kong market and China market are segmented, which is consistent with the previous research by Wang and Jiang (2004).

For these eight stocks, of which H share, A share as well as the HSI and SHA are cointegrated, we estimate an error correction model. The result is reported in Table 5.5. We find that at the 5% level, α_1^H is significant for six stocks, and α_1^A is significant for 3 stocks. To summarize, the majority of price adjustment occurs in HK market for 5 stocks, which implies that China stock market plays a more important role in the price-discovery process; the remaining 3 stocks' A share prices adjust more to the deviation from the equilibrium relationships among the four price series than their H share prices, which implies that the SEHK plays a more important role in the price-discovery process. Overall, for cross-listed stocks which are cointegrated after considering the market movement, we conclude that both markets contributes to the price-discovery process for cross-listed H share and A share. Since

α_1^A is not significant for those 5 stocks, while α_1^H is significant for 2 out of those 3 stocks, which suggests that the H share price adjustment is more frequent than the A share, we conclude that the China stock market plays a dominant role in finding the efficient price of the cross-listed H share and A share stocks.

5.4 A brief analysis of cointegration and the SEHK price-discovery contribution

In our study, eight out of 22 cross-listed H share and A share have shown cointegration relationships, and the SEHK seems to play an important role in the price-discovery process for three of them: Anhui Conch Cement Co Ltd (914), Yanzhou Coal Mining Co Ltd (1171) and Sinopec Yizheng Chemical Fibre Co Ltd (1033). The existence of the cointegration relationship suggests that the prices of H share and A share will not move away from each other taking into account each market's movement. Thus, we can predict the price movement in one market by observing the price in another market in the short run. In this section, we analyze the factors that could determine the existence of cointegration relationship and affect the SEHK price-discovery contribution.

We believe the comparative liquidity of H share and A share could be a major determinant of the cointegration between the cross-listed H share and A share. Therefore, in our study, the independent variables are the measurements of the

liquidity of H share and A share. The first group of measurements is the percentage of tradable A share and listed H share in the firm's total shares outstanding.[10] We also examine the ratio of listed H share to tradable A share. The second group of measurements consists of the market capitalization of H share and tradable A share as well as the ratio of them. We want to see whether the larger the market capitalization of the H share, the higher the probability that cross-listed stocks are cointegrated and SEHK plays a more important role in the price discovery of cross-listed stocks. The third group of measurements is the ratio of average daily volume of H share to A share and the ratio of average daily turnover of H share to A share, which measure the relative trading liquidity of H share and A share.

We estimated a probit model as follows:

$$\text{Probit}(p) = \text{Intercept} + BX, \qquad (25)$$

where Probit(p) denotes the possibility that cross-listed H share and A share are cointegrated, and X is the explanatory variable.

However at the 10% significance level, we find that the t-statistics for the coefficient is not significant for all variables that we examined. The explanatory power of the model is low. If we compare the explanatory variable of each cointegrated stock with the frequency statistics of that variable of the 22 stocks, we

[10] Due to historical reasons, only a fraction of A share is freely tradable in the market.

can get the inference of what kinds of stocks are likely to have a cointegration relationship between their H share and A share. Table 5.6 to Table 5.13 show the 22 cross-listed stocks sorted by each liquidity measurement. The shaded stocks are the stocks that are cointegrated among the four price series. The underlined stocks are the stocks that SEHK contribute more to the price-discovery process.

Table 5.6 displays the 22 stocks sorted by their percentage of tradable A shares and its frequency statistics. For the eight cointegrated stocks, five of them have a smaller percentage of tradable A share than the mean of the 22 stocks. Three cross-listed stocks are in the 1st quantile while only one firm is in the 4th quantile for their percentage of tradable A shares. This implies that the percentage of tradable A share is relatively small for cointegrated firms. For the three stocks that SEHK contribute more to the price-discovery process, two are in the first quantile. This suggests that for cross-listed stocks, SEHK tends to contribute more to the ones with a relatively smaller percentage of tradable A share. From Table 5.7, we can see that the range of the percentage of listed H share is relatively small, from 23.7% to 46.33%. And most of the cross-listed stocks are concentrated around the median of the 22 stocks. Table 5.8 presents the stocks sorted by the ratio of listed H share to tradable A share. The ratios of the five cointegrated stocks are more than the mean ratio for the 22 firms in our sample. For the three stocks which the SEHK plays

more important role in finding the efficient implicit price, two of them have the largest and second largest ratio of listed H share to tradable A share relative to other cointegrated stocks. This suggests that the firm who has issued more H share relative to tradable A share tends to have a cointegration relationship between the H share price and A share price, and a larger share of price-discovery contribution from SEHK.

Table 5.9 exhibits the firms sorted by the market capitalization of tradable A share, and Table 5.10 displays the firms sorted by the market capitalization of H share. From these two tables we see that the market capitalizations of both tradable A share and H share are scattered from the 1st quantile to the 4th quantile for the 22 stocks, and China Petroleum & Chemical Corporation (386) has a substantially larger market capitalization for both A share and H share than other stocks. Table 5.11 shows the firms sorted by the ratio of H share capitalization to tradable A share capitalization. Except for Beiren Printing Machinery Holdings Ltd (187), the ratios for cointegrated stocks are all greater than 1, which suggest that the market capitalization of H share are larger than the market capitalization of tradable A share for most of the cross-listed stocks. Moreover, six out of the eight stocks have a ratio that is greater than the median of 1.93. For the three stocks that SEHK contributes more to the price-discovery process, they seem to have relatively larger ratios than other

cross-listed stocks.

Table 5.12 and Table 5.13 show that the ratios of average daily volume and average daily turnover of H share to A share for the eight cointegrated stocks are scattered from the 1st quantile to the 4th quantile. We can get little inference of cointegration or SEHK's importance in the price discovery for cross-listed H share and A share from the relative trading volume and turnover of H share and A share.

Overall, by studying the distribution of several liquidity measurements, we find that H share price and A share price of the same cross-listed stock tend to cointegrate if the percentage of tradable A share is small, the percentage of H share outstanding is large and the ratio of H share to tradable A share is large. If the ratio of market capitalization of H share to tradable A share is large, the cross-listed stocks tend to be cointegrated. By comparing the liquidity statistics of the three stocks that SEHK contributes more to the price-discovery process with those of other cross-listed stocks, the same liquidity characteristics seems to hold for these stocks.

5.5 The cointegration between H share and A share- Daily analysis

We have used the intraday data to analyze the cointegration and the price-discovery contribution of cross-listed H share and A share. In this section, we use daily closing prices of H share and A share to examine whether the cointegration

exists between the two prices in a daily level.

We collect the daily closing price data for all 29 cross-listed stocks from the Datastream and implement the Johansen cointegration test to two periods. The first period extends from the January 2, 2001 to November 30, 2004. The second periods extends from December 1, 2003 to November 30, 2004. The contemporaneous daily price of Hang Seng Index and Shanghai A index are also collected, and the natural log of them will be used as a proxy for the market movement in the cointegration test.

The Johansen cointegration test is performed on the H share and A share price with the log of Hangseng Index and Shanghai A Index. Since our main concern is to find whether the price series are cointegrated, we use the statistics of $\lambda_{trace}(0)$, of which the null hypothesis is that the number of cointegrating vector is zero, and the alternative hypothesis is that the number of cointegrating vector is equal to or greater than 1. The critical values at the 5% and 10% levels are 53.48 and 49.95 respectively. If the null is rejected, we can conclude that the price series are cointegrated.

The empirical results of the second and the third periods are reported in Table 5.14. For the period of Jan. 2 2001 to Nov. 30 2004, the $\lambda_{trace}(0)$ statistic is significant at the 5% level for 7 firms and is significant at the 10% level for 2 firms. In the period of Dec.1 2003 to Nov. 3 2004, the $\lambda_{trace}(0)$ statistic is significant at the

5% level for 25 firms and 10% level for 1 firm. Overall, the cointegration test shows that the prices of cross-listed H share and A share are more cointegrated in recent years taking into account of market movement. Although there is no arbitrage opportunity in the absence of convertibility between H share and A share, the two prices seem to start to move in tandem in recent years. This could be due to an increase of Chinese investors in H share. In recent years, many Hong Kong security firms have started business in the Mainland to facilitate the mainland investors to trade stocks in SEHK. Since the Mainland traders have more information related to the H share companies, their trading activities possibly drive the price of H share to move with A share.

In this chapter, we investigate the price-discovery contribution of SEHK and the China stock exchanges to 22 cross-listed H shares and A shares. Different from previous researches on the stocks cross-listed on developed countries, at an intraday level, only 2 stocks' H share and A share are cointegrated. Even controlling for the specific market sentiment suggested by Wang and Jiang (2004), only six firms are cointegrated during the 5-month period after SARS. The cointegration test results suggest that the Hong Kong stock market and the China stock market are segmented. For these six cointegrated stocks, the error correction model suggests that the China stock market plays a dominant role in the price-discovery process, since the majority

of price adjustment occurs in the Hong Kong stock market. We also find that if H share is more liquid and the market capitalization of H share is smaller, the cross-listed H share and A share are more likely to cointegrated with each other. Finally, the Johansen test results show that H share and A share prices tend to cointegrate with each other in recent years, suggesting that the Hong Kong stock market and the China stock market start to integrate with each other.

Chapter 6 Conclusion

With the globalization of financial markets, a number of firms choose to cross-list their shares on foreign exchanges. The cross-listings not only occur between developed markets, such as Canadian firms cross-listed on U.S. stock exchanges and American firms cross-listed on European exchanges, but also between emerging and developed markets. In our study, we examine price-discovery contributions of various exchanges to a number of cross-listed Chinese stocks.

We use daily closing price to investigate eight China-backed stocks cross-listed on NYSE and SEHK. We find that the prices of the same stock in SEHK and NYSE are cointegrated with one common factor. With Gonzalo-Granger (1995) PT model and Hasbrouck (1995) IS model, we calculate the price-discovery contribution of NYSE and SEHK with different pair of prices. Both markets contribute to the price-discovery process of the eight stocks. In addition, we find that the SEHK plays a more important role in the price-discovery process of these stocks. We show that the NYSE's contribution is smaller if the stock is also listed on the China stock exchanges.

In the analysis of stocks that cross-listed on the SEHK and China stock exchanges, we find that very few of H shares and A shares are cointegrated with each other. This suggests that these two markets are segmented. For the eight

cointegrated stocks, we estimate an error correction model and conclude that seven out of eight stocks' H share prices adjust to the deviation from the equilibrium relationship among the four price series—H share price, A share price, price of Tracker Fund, and the log of Shanghai A index. The empirical results show that for the cross-listed H share and A share, the China stock market plays a major role in the price-discovery contribution. The analysis of determinants for cointegration and SEHK price-discovery contribution suggests that the stocks that have relatively liquid H share tend to have a cointegration relationship between the H share and A share, and the H share price seems to play a more important role in finding the implicit efficient price for cross-listed stocks. Using the daily data, we find that the H share and A share are cointegrated in recent years, which indicates that the Hong Kong market and China market start to integrate with each other gradually.

Reference

1. Alexander, G.J., G.S. Eun, and S. Janakiramanan. (1987) "Asset Pricing and Dual Listing on Foreign Capital Markets: A note." *Journal of Finance* 42 (1): 151-158.
2. Alexander, G.J., G.S. Eun, and S. Janakiramanan. (1988) "International Listings and Stock Returns: An Empirical Evidence." *Journal of Finance and Quantitative Analysis* 23 (2): 135-151.
3. Amihud, Y., H. Mendelson, and J. Uno. (1999) "Number of Shareholders and Stock Prices: Evidence from Japan." *Journal of Finance* 54 (3): 1169-1184.
4. Baillie, R.T., G.G. Booth, Y. Tse, and T. Zabotina. (2002) "Price Discovery and Common Factor Models." *Journal of Financial Markets* 5: 309-321.
5. Baker, H.K., J.R. Nofsinger, and D.G. Weaver. (2002) "International Cross-Listing and Visibility." *Journal of Financial and Quantitative Analysis* 37 (3): 495–521.
6. Booth, G.G., J.C. Lin, T. Martikainen and Y. Tse. (2002) "Trading and Pricing in Upstairs and Downstairs Stock Markets." *Review of Financial Studies* 15: 1111-1135.
7. Brockman, P., and D.Y. Chung. (1999) "Bid-ask Spread Components in An Order-driven Environment." *Journal of Financial Research* 22(2): 227-246.
8. Chowdhry, B. and V. Nanda. (1991) "Multimarket Trading and Market Liquidity." *Review of Financial Studies* 4 (3): 483–511.
9. Dickey, D.A. and W.A. Fuller. (1981) "Likelihood Ratio Statistics for Autoregressive Time Series with a Unit Root", *Econometrica* (49): 1057-1072.
10. Ding, D.K., F.H.deB Harris, S.T. Lau, and T.H. McInish, (1999) "An Investigation of Price Discovery in Informationally-Linked Markets: Equity Trading In Malaysia And Singapore." *Journal of Multinational Financial Management* 9: 317-329.

11. Domowitz, I., J. Glen, and A. Madhavan. (1998) "International Cross-Listing and Order Flow Migration: Evidence from an Emerging Market." *Journal of Finance* 53: 2001-2027.

12. Enders, W. (1995) *Applied Econometric Time Series* (John Wiley & Sons, New York).

13. Engle, R.F. and C.W.J. Granger. (1987) "Co-Integration and Error Correction: Representation, Estimation, and Testing." *Econometrica* 55 (2): 251-276.

14. Engle, R.F. and B.S. Yoo. (1987) "Forecasting and Testing in Co-Integrated Systems." *Journal of Econometrics*. 35 (1): 143-159.

15. Errunza, V.R., and D.P. Miller. (2000) "Market Segmentation and the Cost of Capital in International Equity Markets." *Journal of Financial and Quantitative Analysis* 35, (4): 577-600.

16. Eun, C.S. and S. Sabherwal. (2003) "Cross-Border Listings and Price Discovery: Evidence from U.S.-Listed Canadian Stocks." *Journal of Finance* 58 (2): 549-574.

17. Foerster, S.R., and A.G. Karolyi. (1993) "International Listings of Stocks: The Case of Canada and the U.S.." *Journal of International Business Studies* 24: 763-784.

18. Foerster, S.R., and A.G. Karolyi. (1998) "Multimarket Trading and Liquidity: A Transaction Data Analysis of Canada-U.S. Interlistings." *Journal of International Financial Markets, Institutions and Money* 8: 393-412.

19. Foerster, S.R., and A.G. Karolyi. (1999) "The Effects of Market Segmentation and Investor Recognition on Asset Prices: Evidence from Foreign Stocks Listing in the U.S.." *Journal of Finance* 54: 981-1013.

20. Foerster, S.R., G.A. Karolyi. (2000) "The Long-Run Performance of Global Equity Offerings." *Journal of Financial and Quantitative Analysis* 35 (4):

499-528.

21. Garbade, K.D., and W.L. Silber. (1979) "Dominant and Satellite Markets: A Study of Dually-Traded Securities." *Review of Economics and Statistics* 61: 455-460.
22. Gonzalo, J., C. Granger. (1995) "Estimation of Common Long-Memory Components in Cointegrated Systems." *Journal of Business & Economic Statistics*, 13 (1): 27-35.
23. Grammig, J., M. Melvin, and C. Schlag. (2005) "Internationally Cross-listed Stock Prices during Overlapping Trading Hours: Price Discovery and Exchange Rate Effects." *Journal of Empirical Finance* 12: 139-164.
24. Harris, F.H. deB., T.H. McInish, G.L. Shoesmith, and R.A. Wood. (1995) "Cointegration, Error Correction, and Price Discovery on Informationally Linked Security Markets." *Journal of Financial and Quantitative Analysis* 30 (4): 563-579.
25. Harris, F.H. deB., T.H. McInish, and R.A. Wood. (2002) "Security Price Adjustment across Exchanges: An Investigation of Common Factor Components for Dow Stocks." *Journal of Financial Markets* 5: 277-308.
26. Hasbrouck, J. (1995) "One Security, Many Markets: Determining the Contributions to Price Discovery." *Journal of Finance* 50 (4): 1175-1199.
27. Hupperets, E. and B. Menkveld. (2000) "Intra-Daily Analysis of Market Integration: Dutch Blue Chips Traded in Amsterdam and New York." *Working paper*, The Wharton School, University of Pennsylvania.
28. Johansen, S., (1988) "Statistical Analysis of Cointegration Vectors." *Journal of Economic Dynamics and Control* 12: 231-254.

29. Kadapakkam, P., L. Misra, and Y. Tse. (2003) "International Price Discovery for Emerging Market Stocks: Evidence from Indian GDRs." *Review of Quantitative Finance and Accounting* 21: 179-199.

30. Kadlec, G.B. and J.J. McConnel. (1994) "The Effect of Market Segmentation and Illiquidity on Asset Prices: Evidence from Exchange Listings." *Journal of Finance* 49 (2): 611-636.

31. Karolyi, G.A.. (1998) "Why Do Companies List Shares Abroad? A Survey of the Evidence and Its Managerial Implications." *Financial Markets, Institutions and Instruments* 7 (1): 1–60.

32. Li, X. (2003) "China: Further Evidence on the Evolution of Stock Markets in Transition Economies." *Scottish Journal of Political Economy* 50 (3): 341-358.

33. Lieberman, O., U. Ben-Zion, and S. Hauser. (1999) "A Characterization of the Price Behavior of International Dual Stocks: An Error Correction Approach" *Journal of International Money and Finance* 18 (2): 289-304.

34. Lima, E.J.A. and B.M.Tabak. (2004) "Tests of the random walk hypothesis for equity markets: evidence from China, Hong Kong and Singapore." *Applied Economics Letters* 11(4): 255-258.

35. Merton, R.C.. (1987) "A Simple Model of Capital Market Equilibrium with Incomplete Information." *The Journal of Finance* 42 (3): 483-510.

36. Miller, D.P.. (1999) "The Market Reaction to International Cross-Listings: Evidence from Depositary Receipts." *Journal of Financial Economics* 51 (1): 103-123.

37. Mittoo, U.R.. (1992) "Managerial Perceptions of the Net Benefits of Foreign Listing: Canadian Evidence." *Journal of International Financial Management and Accounting* 4 (1): 40–62.

38. Nippani, S. and K.M. Washer. (2004) "SARS: A Non-Event for Affected Countries' Stock Markets?" *Applied Financial Economics* 14 (15): 1105-1110.

39. Pascual, R., B. Pascual-Fuster and F. Climent. (2001) "Cross-listing, Price Discovery and the Informativeness of the Trading Process." *Working paper*, Universidad de las Islas Beleares .

40. Schreiber, P.S., and R.A. Schwartz. (1986) "Price Discovery in Securities Markets." *Journal of Portfolio Management* 12: 43-48.

41. Smith, K., and G. Sofianos. (1997) "The Impact of An NYSE Listing on the Global Trading of Non- U.S. Stocks." *Working paper* 97-2, NYSE.

42. Stock, J.H. and M.W. Watson. (1988) "Testing for Common Trends." *Journal of American Statistical Association* 83: 1097-1107.

43. Wang, S.S, and L. Jiang. (2004) "Location of Trade, Ownership Restrictions, and Market Illiquidity: Examining Chinese A- and H-shares." *Journal of Banking & Finance* 28 (6): 1273-1297.

44. Werner, I.M. and A.W. Kleidon. (1996) "U.K. and U.S. Trading of British Cross-Listed Stocks: An Intraday Analysis of Market Integration." *Review of Financial Studies* 9: 619-664.

45. Xu, X.E. and H.G. Fung. (2002) "Information Flows across Markets: Evidence from China-Backed Stocks Dual-Listed in Hong Kong and New York." *The Financial Review* 37 (4): 563-588.

Tables

Table 4.1 China-Backed Companies Cross-listed on Hong Kong and New York

Company Name	SEHK Code	NYSE Ticker	Industry	Sector	SEHK listing Date	NYSE listing Date	Data Base Date	Conversion Ratio	Initial ADRs size in Billion HKD	Mkt Cap in Billion HKD as of 30/12/2004
BEIJING YANHUA PETROCHEMICAL CO. LTD	325	BYH	Basic Materials	Chemicals – Plastics & Rubber	1997-6-25	1997-6-24	1997-6-25	1:8	1.55	3. 80
CHINA EASTERN AIRLINES CO. LTD.	670	CEA	Transportation	Airline	1997-2-5	1997-2-5	1997-2-5	1:100	1.27	2. 68
CHINA SOUTHERN AIRLINES COMPANY LTD.	1055	ZNH	Transportation	Airline	1997-7-31	1998-4-16	1998-4-16	1:50	3.82	3. 70
CHINA MOBILE (HONG KONG) LTD.	941	CHL	Service	Communications Services	1997-10-23	1997-10-22	1997-10-23	1:5	13.88	497.69
GUANGSHEN RAILWAY COMPANY LIMITED	525	GSH	Transportation	Railroads	1996-5-14	1996-5-13	1996-5-14	1:50	3.57	4. 26
HUANENG POWER INTERNATIONAL, INC.	902	HNP	Utilities	Electric Utilities	1998-1-22	1994-10-6	1998-1-22	1:40	4.83	8. 78
SINOPEC SHANGHAI PETROCHEMICAL CO LTD	338	SHI	Energy	Oil & Gas Operations	1993-7-26	1993-7-26	1993-7-26	1:100	1.33	6. 58
YANZHOU COAL MINING COMPANY LIMITED	1171	YZC	Mining	Mines	1998-4-1	1998-4-1	1998-4-1	1:50	1.80	11. 83

Table 4.2 Augmented Dickey-Fuller Unit root test of P_t^{HK}, P_t^{NY}

		Lags	Eq.(13) no constant no trend	Eq.(14) constant but no trend	Eq.(15) constant and trend
BYH	HK	0	-0.2506	-1.4339	-1.9239
	NY	1	-0.3978	-1.6180	-2.0656
CEA	HK	0	-0.6843	-2.2945	-2.2797
	NY	0	-0.5874	-2.0477	-2.0208
CHL	HK	2	-0.5622	-1.6959	-1.6592
	NY	0	-0.6313	-1.8373	-1.7751
GSH	HK	2	-0.8565	-1.6451	-1.2262
	NY	0	-0.8755	-1.6462	-1.1806
HNP	HK	2	0.8493	-0.1531	-2.5062
	NY	0	0.8138	-0.2175	-2.4640
SHI	HK	0	-0.5168	-2.1312	-2.0433
	NY	0	-0.4175	-1.9602	-1.8518
YZC	HK	2	2.2374	1.4848	-0.6013
	NY	2	2.3086	1.5704	-0.5029
ZNH	HK	0	-1.5151	-3.0336*	-4.8472**
	NY	0	-1.4879	-2.9675*	-4.6756**

Note:

The number of lags is determined by Schwartz Bayesian Criterion.

The critical value at the 5% significance level is -1.95 for Eq.(13)

The critical value at the 5% significance level is -2.86 for Eq.(14)

The critical value at the 5% significance level is -3.41 for Eq.(15)

**Indicates statistical significance at the 5% level.

Table 4.3 Engle Granger Cointegration test

	P_t^{HK}, P_t^{NY}		P_t^{HK}, P_{t-1}^{NY}	
	β_1	a_1	β_1	a_1
Company	(t-stat.)	(t-stat.)	(t-stat.)	(t-stat.)
CEA	1.004	-0.819	0.992	-0.651
	(448.744) ***	(-35.964) ***	(360.175) ***	(-31.442) ***
ZNH	1.005	-0.528	1.000	-0.694
	(645.003) ***	(-26.177) ***	(392.925) ***	(-31.826) ***
CHL	0.995	-0.836	0.994	-0.887
	(715.468) ***	(-33.498) ***	(598.842) ***	(-35.263) ***
GSH	0.992	-0.511	0.990	-0.612
	(838.564) ***	(-26.545) ***	(583.845) ***	(-30.043) ***
HNP	1.000	-0.598	1.000	(-0.773)
	(1366.570) ***	(-27.606) ***	(920.070) ***	(-33.514) ***
SHI	1.005	-0.572	1.001	-0.696
	(685.222) ***	(-28.627) ***	(419.981) ***	(-33.056) ***
YZC	0.998	-0.531	1.000	-0.715
	(1167.480) ***	(-25.010) ***	(633.595) ***	(-31.063) ***
BYH	0.994	-0.407	0.994	-0.574
	(466.841) ***	(-22.367) ***	(389.331) ***	(-28.060) ***

Note:

β_1 is estimated coefficient from regression equation: $P_t^{HK} = \beta_0 + \beta_1 P_t^{NY} + e_t$, and $P_t^{HK} = \beta_0 + \beta_1 P_{t-1}^{NY} + e_t$

a_1 is estimated coefficient of Dickey Fuller test of estimated residuals: $\Delta\hat{e}_t = a_1\hat{e}_{t-1} + \varepsilon_t$

The critical value for a_1 at the 1% and 5% level are -3.92 and -3.35

***Indicates statistical significance at the 1% level.

Table 4.4 Engle- Granger Error correction coefficient: obtained by using SEHK(t) and NYSE(t) and SEHK(t) and NYSE(t-1) closing prices

Firm	(P_t^{HK}, P_t^{NY})		(P_t^{HK}, P_{t-1}^{NY})	
	α_1^{HK}	α_1^{NY}	α_1^{HK}	α_1^{NY}
CEA	-0.515	0.122	-0.077	0.322
ZNH	-0.225	0.106	-0.077	0.414
CHL	-0.640	0.000	-0.247	0.583
GSH	-0.189	0.213	0.000	0.330
HNP	-0.324	0.099	-0.122	0.351
SHI	-0.261	0.192	-0.105	0.381
YZC	-0.182	0.179	0.000	0.327
BYH	-0.220	0.000	-0.108	0.203
Mean	-0.299	0.138	-0.094	0.364
Median	-0.225	0.122	-0.105	0.351
St. dev	0.169	0.105	0.073	0.101

Note:

The α_1^{HK} and α_1^{NY} are estimated from the following error correction models:

$$\Delta P_t^{HK} = \alpha_0^{HK} + \alpha_1^{HK}\hat{e}_{t-1} + \sum_{i=1}^{p}\gamma_i \Delta P_{t-i}^{HK} + \sum_{i=1}^{p}\delta_i \Delta P_{t-i}^{NY} + \varepsilon_t^{HK}$$

$$\Delta P_t^{NY} = \alpha_0^{NY} + \alpha_1^{NY}\hat{e}_{t-1} + \sum_{i=1}^{p}\gamma_i \Delta P_{t-i}^{HK} + \sum_{i=1}^{p}\delta_i \Delta P_{t-i}^{NY} + \varepsilon_t^{NY}$$

If the coefficient is not significant, we use zero to substitute it.

Table 4.5 Gonzalo-Granger common factor coefficients and Hasbrouck information shares: obtained from SEHK(t) closing and NYSE(t) closing price

Firm	Cross-market correlation coefficient	Common factor coefficients		Information shares	
		P_t^{HK}	P_t^{NY}	P_t^{HK}	P_t^{NY}
CEA	0.564	0.192	0.808	0.249	0.751
ZNH	0.816	0.320	0.680	0.457	0.543
CHL	0.756	0.000	1.000	0.286	0.714
GSH	0.740	0.530	0.470	0.534	0.466
HNP	0.823	0.234	0.766	0.401	0.599
SHI	0.807	0.424	0.576	0.479	0.521
YZC	0.855	0.496	0.504	0.500	0.500
BYH	0.692	0.000	1.000	0.163	0.837
Mean.	0.757	0.274	0.726	0.384	0.616
Standard dev	0.094	0.206	0.206	0.135	0.135
Median	0.782	0.277	0.723	0.429	0.571

Note:

[a]Coefficients of correlation between the residual from the VECM.

[b]The common factor coefficient vector is estimated according to Gonzalo and Granger (1995).

[c]The information shares are estimated using the Hasbrouck (1995) model. Reported shares are the averages of the lower and upper bounds of the information shares.

Table 4.6 Gonzalo-Granger common factor coefficients and Hasbrouck information shares: obtained from SEHK(t) closing and NYSE(t-1) closing price

Firm	Cross-market correlation coefficients[a]	Common factor coefficients[b]		Information shares[c]	
		P_t^{HK}	P_{t-1}^{NY}	P_t^{HK}	P_{t-1}^{NY}
CEA	0.110	0.807	0.193	0.969	0.031
ZNH	0.194	0.843	0.157	0.953	0.047
CHL	0.529	0.702	0.298	0.729	0.271
GSH	0.239	1.000	0.000	0.972	0.028
HNP	0.375	0.742	0.258	0.843	0.157
SHI	0.209	0.784	0.216	0.932	0.068
YZC	0.113	1.000	0.000	0.994	0.006
BYH	0.373	0.653	0.347	0.757	0.243
Mean	0.268	0.816	0.184	0.894	0.106
Standard dev	0.146	0.128	0.128	0.104	0.104
Median	0.224	0.796	0.205	0.943	0.058

Note:

[a]Coefficients of correlation between the residual from the VECM.

[b]The common factor coefficient vector is estimated according to Gonzalo and Granger (1995).

[c]The information shares are estimated using the Hasbrouck (1995) model. Reported shares are the averages of the lower and upper bounds of the information shares.

Table 4.7 Cross-Sectional analysis of NYSE price discovery contribution

	Gonzalo-Granger common factor coefficient_γ_n		Hasbrouck information share _ln	
	(1)	(2)	(3)	(4)
Intercept	0.39	0.59	0.34	0.48
	(3.10) **	(5.80) ***	(3.85) ***	(8.78) ***
Nvol	0.438	0.52	0.20	0.26
	(0.538)	(1.02)	(0.35)	(0.93)
Lcn		-0.28		-0.21
		(-3.16) **		(-4.37) **
Adjusted R^2	-0.11	0.55	-0.14	0.72
	(5)	(6)	(7)	(8)
Intercept	0.53	0.65	0.43	0.51
	(4.18) ***	(6.57) ***	(5.15) ***	(9.77) ***
ADRSize	-0.03	0.01	-0.03	0.00
	(-0.67)	(0.30)	(-0.90)	(0.16)
Lcn		-0.29		-0.21
		(-2.71) **		(-3.69) **
Adjusted R^2	-0.09	0.47	-0.03	0.67

Note:

t-statistics are in parentheses.

* Indicates statistical significance at the 10% level.

**Indicates statistical significance at the 5% level.

**Indicates statistical significance at the 1% level.

Table 5.1

The companies which issued both H share and A share at the end of Dec. 2003

No.	Company Name	China Exchange	CN Code	HK Code	CN list Date	HK list Date
1	Angang New Steel Co Ltd	SZE	000898	347	12-26-97	07-24-97
2	Anhui Conch Cement Co Ltd	SSE	600585	914	02-07-02	10-21-97
3	Anhui Expressway Co Ltd	SSE	600012	995	01-07-03	11-13-96
4	Beiren Printing Machinery Holdings Ltd	SSE	600860	187	05-06-94	08-06-93
5	China Eastern Airlines Corporation Ltd	SSE	600115	670	11-05-97	02-05-97
6	China Petroleum & Chemical Corporation	SSE	600028	386	10-19-00	08-08-01
7	China Shipping Development Co Ltd	SSE	600026	1138	05-23-02	11-11-94
8	China Southern Airlines Co Ltd	SSE	600029	1055	07-25-03	07-31-97
9	Dongfang Electrical Machinery Co Ltd	SSE	600875	1072	10-18-95	06-06-94
10	Guangdong Kelon Electrical Holdings Co Ltd	SZE	000921	921	07-13-99	07-23-97
11	Guangzhou Pharmaceutical Co Ltd	SSE	600332	874	02-06-01	10-30-97
12	Guangzhou Shipyard International Co Ltd	SSE	600685	317	10-28-93	08-06-93
13	Huaneng Power International, Inc	SSE	600011	902	12-13-01	01-21-98
14	Jiangsu Expressway Co Ltd	SSE	600377	177	06-27-97	01-16-01
15	Jiangxi Copper Co Ltd	SSE	600362	358	01-11-02	06-12-97
16	Jiaoda Kunji High-Tech Co Ltd	SSE	600806	300	01-03-94	12-07-93
17	Jilin Chemical Industrial Co Ltd	SZE	000618	368	10-15-96	05-23-95
18	Jingwei Textile Machinery Co Ltd	SZE	000666	350	12-10-96	02-02-96
19	Luoyang Glass Co Ltd	SSE	600876	1108	11-01-95	07-08-94
20	Maanshan Iron & Steel Co Ltd	SSE	600808	323	01-06-94	11-03-93
21	Nanjing Panda Electronic Co Ltd	SSE	600775	553	11-18-96	05-02-96
22	Northeast Electric Development Co Ltd	SZE	000585	42	12-13-95	07-06-95
23	Shandong Xinhua Pharmaceutical Co Ltd	SZE	000756	719	08-06-97	12-31-96
24	Shenzhen Expressway Co Ltd	SSE	600548	548	12-25-01	03-12-97
25	Sinopec Shanghai Petrochemical Co Ltd	SSE	600688	338	08-11-93	07-26-93
26	Sinopec Yizheng Chemical Fibre Co Ltd	SSE	600871	1033	04-11-95	03-29-94
27	Tianjin Capital Environmental Protection Co Ltd	SSE	600874	1065	06-30-95	05-17-94
28	Tsingtao Brewery Co Ltd	SSE	600600	168	08-27-93	07-15-93
29	Yanzhou Coal Mining Co Ltd	SSE	600188	1171	07-01-98	04-01-98

Note:

Jiangxi Copper Co Ltd and China Petroleum & Chemical Corporation are also listed on London Stock Exchange.

Table 5.2 The sample of cross-listed H share and A share for intraday analysis

HK ID No.	Full Name	Percentage of tradable A shares(%)	A share average daily turnover (Million RMB)	Percentage of listed H shares(%)	H share average daily turnover (Million HKD)	MktCap of H share (Million HKD)
42	Northeast Electric Development Co Ltd	16.44	5.61	29.54	8.05	232.16
168	Tsingtao Brewery Co Ltd	18.87	12.62	38.38	7.71	3,234.46
177	Jiangsu Expressway Co Ltd	2.98	3.20	24.26	24.93	4,435.86
187	Beiren Printing Machinery Holdings Ltd	17.06	0.37	23.70	2.10	261.00
317	Guangzhou Shipyard International Co Ltd	25.57	19.26	31.82	4.25	228.22
323	Maanshan Iron & Steel Co Ltd	9.29	42.62	26.85	136.34	4,730.90
338	Sinopec Shanghai Petrochemical Co Ltd	10.00	18.34	32.36	45.50	6,803.60
347	Angang New Steel Co Ltd	25.39	21.27	30.06	57.64	3,106.10
358	Jiangxi Copper Co Ltd	8.63	25.44	43.41	73.29	4,463.70
386	China Petroleum & Chemical Corporation	18.87	64.30	38.38	140.49	50,005.85
548	Shenzhen Expressway Co Ltd	7.57	7.32	34.28	13.53	1,958.45
553	Nanjing Panda Electronic Co Ltd	8.85	10.25	36.95	10.52	450.12
670	China Eastern Airlines Corporation Ltd	6.16	6.39	32.20	32.43	2,350.43
902	Huaneng Power International, Inc	4.17	20.56	25.00	112.05	9,781.79
914	Anhui Conch Cement Co Ltd	15.93	23.38	34.50	23.33	4,301.68
921	Guangdong Kelon Electrical Holdings Co Ltd	19.61	2.99	46.33	11.08	1,521.24
1033	Sinopec Yizheng Chemical Fibre Co Ltd	5.00	16.60	35.00	40.79	2,310.00
1065	Tianjin Capital Environmental Protection Co Ltd	11.35	3.11	25.57	6.97	816.00
1072	Dongfang Electrical Machinery Co Ltd	13.33	6.49	37.78	5.83	542.30
1108	Luoyang Glass Co Ltd	7.14	1.28	35.72	2.80	267.50
1138	China Shipping Development Co Ltd	10.52	42.69	38.97	13.63	7,037.28
1171	Yanzhou Coal Mining Co Ltd	6.27	8.23	35.54	17.28	8,394.60

Note: The Mktcap is computed as average daily H share price during the 5 month period in the study with H shares outstanding.

Table 5.3 Unit root test of intraday data at 15-minute interval

HK Code		lags	Eq.(13) no constant no trend	Eq.(14) constant but no trend		Eq.(15) constant and trend	
42	H	1	0.3120	-2.7975		-2.8195	
	A	0	-0.9917	-1.2690		-2.0672	
168	H	1	1.1078	-1.1118		-1.9341	
	A	0	0.1785	-2.9629	**	-2.8919	
177	H	1	0.6604	-1.5492		-2.0494	
	A	1	-1.8711	-1.0133		-0.8816	
187	H	1	0.8688	-2.1645		-2.4695	
	A	0	-0.2875	-1.6166		-1.9398	
317	H	9	-0.0460	-2.8997	**	-3.1430	
	A	0	0.2104	-3.1284	**	-1.7722	
323	H	0	1.1519	-1.5000		-2.2595	
	A	0	0.0636	-1.2606		-1.2528	
338	H	1	1.6904	-0.3747		-1.3842	
	A	0	-0.1640	-1.5346		-1.5158	
347	H	1	1.6646	-1.0786		-2.5773	
	A	2	1.1281	0.5377		-0.6364	
358	H	0	1.6118	-0.7863		-1.9836	
	A	0	1.0420	-0.577		-1.8238	
386	H	1	0.6920	0.3526		-2.8179	
	A	0	0.3526	-0.9803		-1.1605	
548	H	1	0.5865	-2.7935		-3.3753	
	A	0	-0.4627	-1.2267		-3.0303	
553	H	0	0.1601	-2.5086		-2.5467	
	A	0	-0.5812	-0.7937		-2.3193	
670	H	1	-2.3193	-1.8704		-3.4100	
	A	0	-0.2786	-2.4390		-4.0550	**
902	H	2	0.8255	-1.7896		-1.8515	
	A	0	-0.1530	-2.3035		-2.4894	

Table 5,3 Continued

914	H	0	1.5697	-0.6555		-1.7875
	A	0	1.3028	-0.9013		-1.6054
921	H	0	1.1026	-1.1764		-2.5225
	A	1	-0.8868	-1.5155		-3.3909
1033	H	1	1.1091	-0.8350		-1.7311
	A	0	0.3355	-1.3010		-1.9725
1065	H	1	0.2918	-2.6794		-2.5666
	A	3	-0.4526	-1.8996		-2.1971
1072	H	1	0.9058	-1.9101		-2.7027
	A	0	-0.1252	-2.1287		-1.6507
1108	H	0	0.0967	-2.6981		-2.4588
	A	0	-1.2700	-1.0148		-2.2194
1138	H	0	1.0355	-1.1942		-2.5569
	A	0	1.3731	-0.7285		-2.5105
1171	H	0	1.2065	-0.7823		-2.3742
	A	0	-1.2437	-19.6135	**	-1.1025
HSI		2	1.5537	-1.2319		-2.6115
SHA		0	-0.6576	-1.3473		-2.0202

Note:

The number of lags is determined by Schwartz Bayesian Criterion.

The critical value at the 5% significance level is -1.95 for Eq.(13)

The critical value at the 5% significance level is -2.86 for Eq.(14)

The critical value at the 5% significance level is -3.41 for Eq.(15)

**Indicates statistical significance at the 5% level

Table 5.4 Engle-Granger Cointegration test of 4 series:

HK Code	Estimates for cointegration regression, coefficient and t-stat. $P_t^H = \beta_0 + \beta_1 P_t^A + \beta_2 P_t^{HSI} + \beta_3 P_t^{SHA} + e_t$				Cointegration test, coefficient and t-stat $\Delta\hat{e}_t = a_1 \hat{e}_{t-1} + \varepsilon_t$	
	β_0	β_1	β_2	β_3	a_1	
42	-4.74	-0.005	0.09	1.52	-0.03	
	(-5.11)	(-0.43)	(15.99)	(5.40)	(-3.60)	
168	66.32	1.49	0.77	-25.39	-0.03	
	(9.43)	(23.61)	(17.40)	(-11.84)	(-3.66)	
177	-33.89	-0.13	0.28	11.22	-0.02	
	(-10.37)	(-6.71)	(12.74)	(10.41)	(-3.40)	
187	-1.19	0.09	0.37	-0.29	-0.07	
	(-0.91)	(9.82)	(48.30)	(-0.73)	(-6.13)	***
317	-2.99	0.09	0.16	0.67	-0.01	
	(-1.82)	(9.51)	(15.02)	(1.37)	(-2.52)	
323	4.38	0.44	0.22	-2.07	-0.02	
	(2.17)	(25.35)	(17.87)	(-3.43)	(-3.61)	
338	5.13	0.52	0.19	-2.3	-0.02	
	(2.77)	(30.96)	(17.09)	(-4.16)	(-3.47)	
347	-4.97	0.55	0.38	-2.76	-0.03	
	(1.96)	(-22.73)	(22.80)	(-3.65)	(-3.80)	
358	21.40	0.86	0.19	-8.18	-0.03	
	(9.66)	(44.18)	(12.52)	(-12.44)	(-3.81)	
386	-3.25	0.04	0.20	1.04	-0.03	
	(-1.88)	(1.42)	(18.27)	(2.01)	(-3.83)	*
548	1.97	0.14	0.18	-0.82	-0.04	
	(1.39)	(13.58)	(21.82)	(-1.88)	(-4.58)	**
553	26.67	0.26	0.14	-8.96	-0.02	
	(9.17)	(31.28)	(7.83)	(-10.23)	(-3.30)	
670	-7.54	-0.28	0.13	2.67	-0.05	
	(-8.57)	(-9.74)	(33.39)	(9.05)	(-5.58)	***
902	-7.65	-0.15	0.86	3.77	-0.03	
	(-1.82)	(-6.30)	(33.97)	(2.94)	(-3.70)	
914	-18.23	1.18	1.04	0.96	-0.04	
	(-2.95)	(50.09)	(25.51)	(0.53)	(-4.53)	**
921	4.47	-0.49	0.50	-1.28	-0.03	
	(0.98)	(-10.87)	(23.15)	(-0.88)	(-3.63)	

Table 5.4 Continued.

1033	4.16	0.36	0.14	-1.87	-0.03	
	(3.30)	(36.81)	(16.89)	(-4.97)	(-3.97)	*
1065	-1.64	0.13	0.07	0.69	-0.01	
	(-0.68)	(4.40)	(5.02)	(0.93)	(-2.89)	
1072	-13.59	-0.12	0.40	3.85	-0.03	
	(-5.84)	(-9.71)	(26.77)	(5.53)	(-3.82)	
1108	4.78	0.13	0.09	-1.65	-0.02	
	(3.52)	(14.12)	(11.63)	(-3.98)	(-3.10)	
1138	-6.36	0.19	0.88	-0.15	-0.05	
	(-1.85)	(6.36)	(36.38)	(-0.14)	(-4.94)	***
1171	-34.29	0.20	1.08	8.01	-0.19	
	(-9.16)	(13.98)	(47.95)	(7.18)	(-10.07)	***

Note:

For estimated a_1

Critical value at the 1% significant level is -4.68.

Critical value at the 5% significant level is -4.12.

Critical value at the 10% significant level is -3.83.

* Indicates statistical significance at the 10% level.

**Indicates statistical significance at the 5% level.

**Indicates statistical significance at the 1% level.

Table 5.5 Error correction coefficient for intraday cointegrated H share and A share

HK Code		Coefficient	Std Error	T-Statistics	*p*-value	
187	Lags=1					
	α_1^H	-0.036	0.010	-3.66	0	***
	α_1^A	-0.017	0.015	-1.13	0.257	
386	lags=1					
	α_1^H	-0.017	0.007	-2.371	0.018	**
	α_1^A	0	0.004	0.134	0.893	
548	lags=1					
	α_1^H	-0.020	0.009	-2.307	0.021	**
	α_1^A	0.018	0.017	1.059	0.290	
670	Lags=1					
	α_1^H	-0.023	0.009	-2.610	0.009	***
	α_1^A	-0.015	0.014	-1.021	0.308	
914	Lags=1					
	α_1^H	-0.008	0.006	-1.211	0.226	
	α_1^A	0.014	0.004	3.189	0.001	***
1033	lags=1					
	α_1^H	-0.011	0.007	-1.702	0.089	*
	α_1^A	0.032	0.014	2.344	0.019	**
1138	lags=1					
	α_1^H	-0.016	0.008	-2.006	0.045	**
	α_1^A	-0.001	0.005	-0.107	0.915	
1171	lags=1					
	α_1^H	-0.016	0.008	-2.107	0.035	**
	α_1^A	0.353	0.071	4.95	0	***

Note:

p is determined by Schwartz Bayesian Criterion.

* Indicates statistical significance at the 10% level.

**Indicates statistical significance at the 5% level.

**Indicates statistical significance at the 1% level.

Table 5.6 Firms sorted by the percentage of tradable A shares

HK Code	Full Name	TRADABIE_A
177	Jiangsu Expressway Co Ltd	2.98
902	Huaneng Power International, Inc	4.17
1033	Sinopec Yizheng Chemical Fibre Co Ltd	5.00
670	China Eastern Airlines Corporation Ltd	6.16
1171	Yanzhou Coal Mining Co Ltd	6.27
1108	Luoyang Glass Co Ltd	7.14
548	Shenzhen Expressway Co Ltd	7.57
358	Jiangxi Copper Co Ltd	8.63
553	Nanjing Panda Electronic Co Ltd	8.85
323	Maanshan Iron & Steel Co Ltd	9.29
338	Sinopec Shanghai Petrochemical Co Ltd	10.00
1138	China Shipping Development Co Ltd	10.52
1065	Tianjin Capital Environmental Protection Co Ltd	11.35
1072	Dongfang Electrical Machinery Co Ltd	13.33
914	Anhui Conch Cement Co Ltd	15.93
42	Northeast Electric Development Co Ltd	16.44
187	Beiren Printing Machinery Holdings Ltd	17.06
168	Tsingtao Brewery Co Ltd	18.87
386	China Petroleum & Chemical Corporation	18.87
921	Guangdong Kelon Electrical Holdings Co Ltd	19.61
347	Angang New Steel Co Ltd	25.39
317	Guangzhou Shipyard International Co Ltd	25.57

Statistics

		TRADABIE_A
N	Valid	22.00
Mean		12.23
Median		10.26
Std. Deviation		6.60
Minimum		2.98
Maximum		25.57
Percentiles	25	6.92
	50	10.26
	75	17.51

Note: TRADABLE_A denotes the percentage of A share that is tradable in China stock market

Table 5.7 Firms sorted by the percentage of listed H shares

HK Code	Full Name	LISTED_H
187	Beiren Printing Machinery Holdings Ltd	23.70
177	Jiangsu Expressway Co Ltd	24.26
902	Huaneng Power International, Inc	25.00
1065	Tianjin Capital Environmental Protection Co Ltd	25.57
323	Maanshan Iron & Steel Co Ltd	26.85
42	Northeast Electric Development Co Ltd	29.54
347	Angang New Steel Co Ltd	30.06
317	Guangzhou Shipyard International Co Ltd	31.82
670	China Eastern Airlines Corporation Ltd	32.20
338	Sinopec Shanghai Petrochemical Co Ltd	32.36
548	Shenzhen Expressway Co Ltd	34.28
914	Anhui Conch Cement Co Ltd	34.50
1033	Sinopec Yizheng Chemical Fibre Co Ltd	35.00
1171	Yanzhou Coal Mining Co Ltd	35.54
1108	Luoyang Glass Co Ltd	35.72
553	Nanjing Panda Electronic Co Ltd	36.95
1072	Dongfang Electrical Machinery Co Ltd	37.78
168	Tsingtao Brewery Co Ltd	38.38
386	China Petroleum & Chemical Corporation	38.38
1138	China Shipping Development Co Ltd	38.97
358	Jiangxi Copper Co Ltd	43.41
921	Guangdong Kelon Electrical Holdings Co Ltd	46.33

Statistics

		LISTED_H
N	Valid	22.00
Mean		33.48
Median		34.39
Std. Deviation		6.09
Minimum		23.70
Maximum		46.33
Percentiles	25	28.87
	50	34.39
	75	37.93

Note: LISTED_H denotes the percentage of listed H share of the firm.

Table 5.8 Firms sorted by the ratio of listed H share to tradable A share

HK Code	Full Name	RL_HA
347	Angang New Steel Co Ltd	1.18
317	Guangzhou Shipyard International Co Ltd	1.24
187	Beiren Printing Machinery Holdings Ltd	1.39
42	Northeast Electric Development Co Ltd	1.80
168	Tsingtao Brewery Co Ltd	2.03
386	China Petroleum & Chemical Corporation	2.03
914	Anhui Conch Cement Co Ltd	2.17
1065	Tianjin Capital Environmental Protection Co Ltd	2.25
921	Guangdong Kelon Electrical Holdings Co Ltd	2.36
1072	Dongfang Electrical Machinery Co Ltd	2.83
323	Maanshan Iron & Steel Co Ltd	2.89
338	Sinopec Shanghai Petrochemical Co Ltd	3.24
1138	China Shipping Development Co Ltd	3.70
553	Nanjing Panda Electronic Co Ltd	4.18
548	Shenzhen Expressway Co Ltd	4.53
1108	Luoyang Glass Co Ltd	5.00
358	Jiangxi Copper Co Ltd	5.03
670	China Eastern Airlines Corporation Ltd	5.23
1171	Yanzhou Coal Mining Co Ltd	5.67
902	Huaneng Power International, Inc	6.00
1033	Sinopec Yizheng Chemical Fibre Co Ltd	7.00
177	Jiangsu Expressway Co Ltd	8.14

Statistics

		RL_HA
N	Valid	22.00
Mean		3.63
Median		3.06
Std. Deviation		1.97
Minimum		1.18
Maximum		8.14
Percentiles	25	2.03
	50	3.06
	75	5.08

Note: RL_HA denotes the ratio of the percentage of listed H share to the percentage of listed A share.

Table 5.9 Firms sorted by the market capitalization of tradable A share

HK Code	Full Name	MKTCAP_A
1108	Luoyang Glass Co Ltd	245.75
1072	Dongfang Electrical Machinery Co Ltd	465.28
187	Beiren Printing Machinery Holdings Ltd	471.40
42	Northeast Electric Development Co Ltd	526.98
317	Guangzhou Shipyard International Co Ltd	688.48
1065	Tianjin Capital Environmental Protection Co Ltd	717.42
1033	Sinopec Yizheng Chemical Fibre Co Ltd	933.96
1171	Yanzhou Coal Mining Co Ltd	954.48
670	China Eastern Airlines Corporation Ltd	1,185.85
553	Nanjing Panda Electronic Co Ltd	1,214.89
358	Jiangxi Copper Co Ltd	1,215.09
921	Guangdong Kelon Electrical Holdings Co Ltd	1,253.25
548	Shenzhen Expressway Co Ltd	1,259.29
177	Jiangsu Expressway Co Ltd	1,427.83
914	Anhui Conch Cement Co Ltd	1,705.66
168	Tsingtao Brewery Co Ltd	1,720.75
1138	China Shipping Development Co Ltd	2,119.81
323	Maanshan Iron & Steel Co Ltd	2,201.89
338	Sinopec Shanghai Petrochemical Co Ltd	2,832.45
347	Angang New Steel Co Ltd	3,043.84
902	Huaneng Power International, Inc	3,615.57
386	China Petroleum & Chemical Corporation	9,958.49

Statistics

		MKTCAP_A
N	Valid	22.00
Mean		1807.20
Median		1234.17
Std. Deviation		2023.61
Minimum		245.75
Maximum		9958.49
Percentiles	25	710.19
	50	1234.17
	75	2140.33

Note: MKTCAP_A denotes the market capitalization of tradable A shares in HKD in millions.

Table 5.10 Firms sorted by the market capitalization of H share

HK Code	Full Name	MKTCAP_H
317	Guangzhou Shipyard International Co Ltd	228.23
42	Northeast Electric Development Co Ltd	232.16
187	Beiren Printing Machinery Holdings Ltd	261.00
1108	Luoyang Glass Co Ltd	267.50
553	Nanjing Panda Electronic Co Ltd	450.12
1072	Dongfang Electrical Machinery Co Ltd	542.30
1065	Tianjin Capital Environmental Protection Co Ltd	816.00
921	Guangdong Kelon Electrical Holdings Co Ltd	1,521.24
548	Shenzhen Expressway Co Ltd	1,958.45
1033	Sinopec Yizheng Chemical Fibre Co Ltd	2,310.00
670	China Eastern Airlines Corporation Ltd	2,350.43
347	Angang New Steel Co Ltd	3,106.10
168	Tsingtao Brewery Co Ltd	3,234.46
914	Anhui Conch Cement Co Ltd	4,301.68
177	Jiangsu Expressway Co Ltd	4,435.86
358	Jiangxi Copper Co Ltd	4,463.70
323	Maanshan Iron & Steel Co Ltd	4,730.90
338	Sinopec Shanghai Petrochemical Co Ltd	6,803.60
1138	China Shipping Development Co Ltd	7,037.28
1171	Yanzhou Coal Mining Co Ltd	8,394.60
902	Huaneng Power International, Inc	9,781.79
386	China Petroleum & Chemical Corporation	50,005.85

Statistics

		MKTCAP_H
N	Valid	22.00
Mean		5,328.78
Median		2,728.26
Std. Deviation		10,366.74
Minimum		228.23
Maximum		50,005.85
Percentiles	25	519.26
	50	2,728.26
	75	5,249.07

Note: MKTCAP_H denotes the market capitalization of H share in HKD in millions.

Table 5.11 Firms sorted by the ratio of H share capitalization to tradable A share capitalization

HK Code	Full Name	RMCAP_HA
317	Guangzhou Shipyard International Co Ltd	0.33
553	Nanjing Panda Electronic Co Ltd	0.37
42	Northeast Electric Development Co Ltd	0.44
187	Beiren Printing Machinery Holdings Ltd	0.55
347	Angang New Steel Co Ltd	1.02
1108	Luoyang Glass Co Ltd	1.09
1065	Tianjin Capital Environmental Protection Co Ltd	1.14
1072	Dongfang Electrical Machinery Co Ltd	1.17
921	Guangdong Kelon Electrical Holdings Co Ltd	1.21
548	Shenzhen Expressway Co Ltd	1.56
168	Tsingtao Brewery Co Ltd	1.88
670	China Eastern Airlines Corporation Ltd	1.98
323	Maanshan Iron & Steel Co Ltd	2.15
338	Sinopec Shanghai Petrochemical Co Ltd	2.40
1033	Sinopec Yizheng Chemical Fibre Co Ltd	2.47
914	Anhui Conch Cement Co Ltd	2.52
902	Huaneng Power International, Inc	2.71
177	Jiangsu Expressway Co Ltd	3.11
1138	China Shipping Development Co Ltd	3.32
358	Jiangxi Copper Co Ltd	3.67
386	China Petroleum & Chemical Corporation	5.02
1171	Yanzhou Coal Mining Co Ltd	8.79

Statistics

		RMCAP_HA
N	Valid	22
Mean		2.223
Median		1.9309
Std. Deviation		1.892
Minimum		0.33
Maximum		8.79
Percentiles	25	1.0715
	50	1.9309
	75	2.8058

Note: RMCAP_HA denotes the ratio of market capitalization of H share to market capitalization of tradable A share.

Table 5.12 Firms sorted by the ratio of average daily trading volume of H share to A share

HK Code	Full Name	RV_HA
317	Guangzhou Shipyard International Co Ltd	0.96
168	Tsingtao Brewery Co Ltd	1.08
914	Anhui Conch Cement Co Ltd	1.44
187	Beiren Printing Machinery Holdings Ltd	1.66
1138	China Shipping Development Co Ltd	1.94
1072	Dongfang Electrical Machinery Co Ltd	3.64
386	China Petroleum & Chemical Corporation	3.76
347	Angang New Steel Co Ltd	4.42
553	Nanjing Panda Electronic Co Ltd	4.72
338	Sinopec Shanghai Petrochemical Co Ltd	5.46
42	Northeast Electric Development Co Ltd	5.54
548	Shenzhen Expressway Co Ltd	6.43
1065	Tianjin Capital Environmental Protection Co Ltd	7.13
1171	Yanzhou Coal Mining Co Ltd	7.18
323	Maanshan Iron & Steel Co Ltd	7.31
358	Jiangxi Copper Co Ltd	7.52
902	Huaneng Power International, Inc	7.80
1033	Sinopec Yizheng Chemical Fibre Co Ltd	8.66
921	Guangdong Kelon Electrical Holdings Co Ltd	9.83
1108	Luoyang Glass Co Ltd	13.21
670	China Eastern Airlines Corporation Ltd	17.89
177	Jiangsu Expressway Co Ltd	23.30

Statistics

		RV_HA
N	Valid	22.00
Mean		6.86
Median		5.98
Std. Deviation		5.47
Minimum		0.96
Maximum		23.30
Percentiles	25	3.22
	50	5.98
	75	8.01

Note: RV_HA denotes the ratio of average daily trading volume of H share to A share.

Table 5.13 Firms sorted by the ratio of average daily turnover of H share to A share

HK Code	Full Name	RT_HA
317	Guangzhou Shipyard International Co Ltd	0.23
1138	China Shipping Development Co Ltd	0.34
168	Tsingtao Brewery Co Ltd	0.65
1072	Dongfang Electrical Machinery Co Ltd	0.95
914	Anhui Conch Cement Co Ltd	1.06
553	Nanjing Panda Electronic Co Ltd	1.09
42	Northeast Electric Development Co Ltd	1.52
548	Shenzhen Expressway Co Ltd	1.96
1171	Yanzhou Coal Mining Co Ltd	2.22
1108	Luoyang Glass Co Ltd	2.31
386	China Petroleum & Chemical Corporation	2.32
1065	Tianjin Capital Environmental Protection Co Ltd	2.37
1033	Sinopec Yizheng Chemical Fibre Co Ltd	2.60
338	Sinopec Shanghai Petrochemical Co Ltd	2.63
347	Angang New Steel Co Ltd	2.87
358	Jiangxi Copper Co Ltd	3.05
323	Maanshan Iron & Steel Co Ltd	3.39
921	Guangdong Kelon Electrical Holdings Co Ltd	3.93
670	China Eastern Airlines Corporation Ltd	5.38
902	Huaneng Power International, Inc	5.78
187	Beiren Printing Machinery Holdings Ltd	5.91
177	Jiangsu Expressway Co Ltd	8.26

Statistics

		RT_HA
N	Valid	22.00
Mean		2.76
Median		2.34
Std. Deviation		2.03
Minimum		0.23
Maximum		8.26
Percentiles	25	1.08
	50	2.34
	75	3.52

Note: RT_HA denotes the ratio of average daily turnover of H share to A share.

Table 5.14 Johansen cointegration test on daily H share and A share prices

Company	1/2/2001-11/30/2004	12/1/2003-11/30/2004
Northeast Electric Development Co Ltd	54.66 **	54.50 **
Tsingtao Brewery Co Ltd	43.18	67.03 **
Jiangsu Expressway Co Ltd	46.60	58.90 **
Beiren Printing Machinery Holdings Ltd	33.95	68.49 **
Jiaoda Kunji High-Tech Co Ltd	35.27	62.14 **
Guangzhou Shipyard International Co Ltd	49.60	55.89 **
Maanshan Iron & Steel Co Ltd	40.82	51.03 *
Sinopec Shanghai Petrochemical Co Ltd	47.24	36.03
Angang New Steel Co Ltd	43.53	63.11 **
Jingwei Textile Machinery Co Ltd	44.79	67.39 **
Jiangxi Copper Co Ltd	43.44	64.77 **
Jilin Chemical Industrial Co Ltd	55.14 **	73.67 **
China Petroleum & Chemical Corporation	37.46	84.44 **
Shenzhen Expressway Co Ltd	40.93	100.68 **
Nanjing Panda Electronic Co Ltd	39.54	64.74 **
China Eastern Airlines Corporation Ltd	49.97 *	44.62
Shandong Xinhua Pharmaceutical Co Ltd	37.04	79.05 **
Guangzhou Pharmaceutical Co Ltd	35.53	77.93 **
Huaneng Power International, Inc	43.22	53.68 **
Anhui Conch Cement Co Ltd	37.39	57.25 **
Guangdong Kelon Electrical Holdings Co Ltd	51.22 *	58.22 **
Anhui Expressway Co Ltd	46.15	59.19 **
Sinopec Yizheng Chemical Fibre Co Ltd	60.59 **	79.74 **
China Southern Airlines Co Ltd	66.36 **	70.29 **
Tianjin Capital Environmental Protection Co Ltd	45.73	47.70
Dongfang Electrical Machinery Co Ltd	58.03 **	59.39 **
Luoyang Glass Co Ltd	38.84 **	77.17 **
China Shipping Development Co Ltd	58.59 **	79.51 **
Yanzhou Coal Mining Co Ltd	46.53	53.77 **

Note:

The critical value at the 5% level is 53.48, and the critical value at the 10% level is 49.95.

* Indicates statistical significance at the 10% level.

**Indicates statistical significance at the 5% level.

**Indicates statistical significance at the 1% level.